SCIENTIFIC AMERICAN MONTHLY

VOL. III. TABLE OF CONTENTS, JUNE, 1921 No. 6.

Planetary Motions and the Einstein Theories 484
Egyptian Life Four Thousand Years Ago..... 487
The Roger Bacon Manuscript 492
Visual Illusions in the Arts 497
Principles of Modern Psychology 501
Chemical War on Disease 503
Vaccines and Serums 507
How Bivalves Feed 511
Foods Under the Microscope 513
Searching the World for New Food Plants..... 516
Flavors, Odors and Infra-red Rays 519
Light and Chemical Energy 523
Developing without a Dark Room 526
Experimental Phonetics 527
Motion Pictures Shown in Relief 531
Artificial Pearls 533
Typewriter Inks and Ribbons 536
True Nature of Soap Solutions 538
Warming Buildings with Refrigerating Plants 539
Blast Furnace Flue Dust Recovery 543
The Romance of Platinum 547
"Mountain Craft" 551

Notes and Short Articles

The Chemist Militant 483
Seaplane Forest Patrol 483
New Observations on the Variability of the Sun 486
Bengal's Disastrous Cyclone 486
Old Persian Colony in Africa 491
Trephining Among Prehistoric Indians 496
The Diet of Apes 502
An "Oven Plant" 518
Paper Fabrics Again 518
The Fragrance of the Earth 522
Vegetative and Reproductive Functions and Metabolism... 522
The Optical Industry 532
Improvements in Dyeing 532
How to Weld Cast Iron Electrically 542
Molybdenum Steels 546
Substitutes for Platinum 550
Future Fuel 550
Paper Making Materials 562

Departments

Research Work of the United States Bureau of Standards 556
Refrigeration Constants. White Coat Cast Iron Enamel. Looking into the Cylinder of a Gasoline Engine in Operation. Developing Standard Specifications for Paper Bags Used in Connection with Cement and Lime. Meeting of Executive Committee of the American Engineering Standards Committee. Committee Meeting on Revision of Tire Specifications. Meeting of the Advisory Committee on Non-Ferrous Alloys. Discoloration of Indiana Limestone. Non-Ferrous Etching Reagents. Strength Tests of Ideal Walls. Investigation into the Corrosion of Sheet Duralumin.

Notes on Science in America 558
Minimum Sound Energy for Audition. Vulcanism and Mountain-Making. The Measurement of Sea Water Salinity. Height, Hygiene and Physical Training. A New Physical Test for a Man. An Ammonia Gas Problem and Its Solution.

Science and National Progress 561
Recent Work of the Russian Academy of Science.

Progress in the Field of Applied Chemistry 563
At the Silk Exposition. Chemical Monographs. A New Achievement in American Dyes. New Process for Making Steel. Sixty-first Meeting of the American Chemical Society. Industrial Fellowships. Solvents Produced by Bacteria.

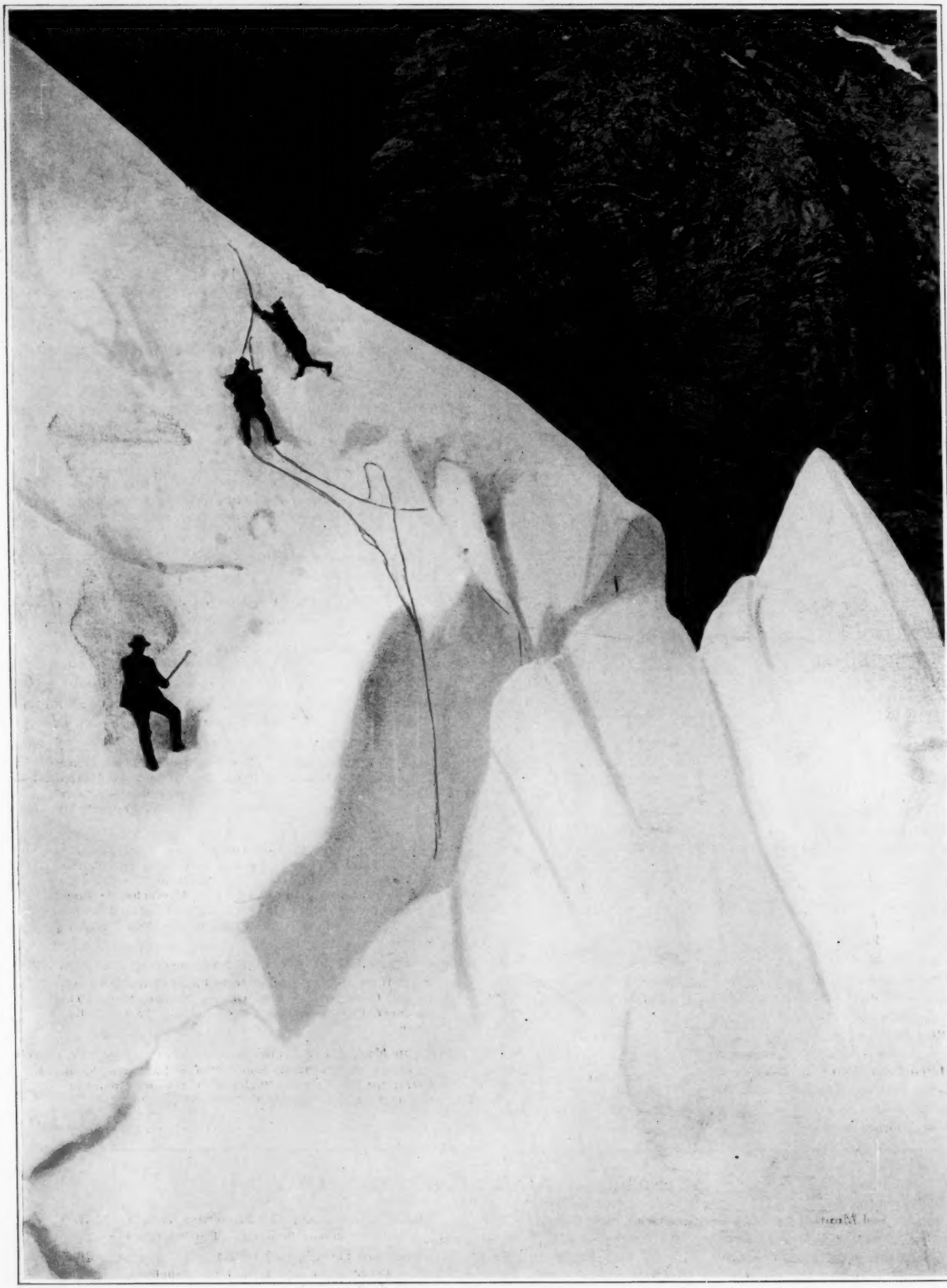
Progress in the Field of Electricity 565
Moving Platforms for Cross-town Lines. The Distribution of Electricity. The Deleterious Effect of Fibers on the Electric Insulating Power of Oils. Hydroelectric Progress in Canada During Recent Past. Electrical Resistance of Metals. The Limitations of the Stop Watch as a Precision Instrument.

Survey of Progress in Mechanical Engineering 567
Aircraft Statistics. Coats Steam Car. Columbian Flask Steam Condenser. Palm Oil as Engine Fuel. The Sprenger Process of Making Concrete. Water Cooling Towers.

Progress in Mining and Metallurgy 569
Firedamp in the Gold Mines of the Far East Rand. Retort for Assaying Oil Shales for Oil Yield. Investigation of Fatigue of Metals Under Stress.

Index 571

SCIENTIFIC AMERICAN MONTHLY
Edited by A. RUSSELL BOND
Published Monthly by Scientific American Publishing Co. **Munn & Company, 233 Broadway, New York, N. Y.**
Charles Allen Munn, President. Orson D. Munn, Treasurer. Allan C. Hoffman, Secretary, all at 233 Broadway
Scientific American Monthly . . . per year $7.00 **Scientific American (established 1845) . . . per year $6.00**
The combined subscription rates and rates to foreign countries, including Canada, will be furnished upon application
Remit by postal or express money order, bank draft or check
(Entered as second class matter, December 15, 1887, at the Post Office at New York, N. Y., under act of March 3, 1879)
Copyright, 1921, Scientific American Publishing Co.



"MOUNTAIN CRAFT"—A STIFF CLIMB UP THE EISMEER, THE FAMOUS SEA OF ICE, IN THE JUNGFRAU DISTRICT OF THE BERNESE OBERLAND, SWITZERLAND (SEE PAGE 551)

SCIENTIFIC AMERICAN MONTHLY

VOLUME III
NUMBER 6

NEW YORK, JUNE, 1921

60 CENTS A COPY
$7 00 A YEAR

THE CHEMIST MILITANT

THE important part that chemistry played in the great World War is now an old story. Today we are being warned that new terrors are being prepared for the next great struggle which will make the recent one pale by comparison. But not very much is being written about the chemical war that is now being waged in which millions of the enemy are being poisoned by chemicals—the war against the hordes of parasites that invade the human organism.

Remarkable progress has been made in the use of serums for combating certain diseases, but there are some protozoic infections which do not yield to the serum treatment, and in such cases the chemist is called in to wage war with poisons. His problem is to find a substance which will kill the pathogenic parasites without doing injury to the human organism.

The problem is complicated however by the fact that living matter is to be dealt with. Reactions that seem perfectly satisfactory as performed in the test tube fail to show the same reaction in the human body. Experiments on animals vary with different animals and hence offer no definite clue as to how the human organism will behave under the same conditions. There is even a difference of behavior in different parts of the same animal. So many variables enter into the problem that the chemist's problem of selective poisoning is an exceedingly complex one. How may he be sure that the foe will partake of the poison and the friend will abstain?

Ehrlich in his researches that led eventually to the discovery of "salvarsan," worked upon a theory borrowed from that upon which the synthetic production of dyestuffs is based. He recognized a chemical affinity between certain chemical groups in the living cells and certain chemical groups in the substances they absorbed. He pictured the living cell as consisting of a central nucleus surrounded by a group of atomic bonds which he termed "receptors." According to the theory these "receptors" are the active guardians of the nucleus and exercise selective judgment as to what may be admitted to the nucleus. They are very mobile and ready to detach themselves from or reunite themselves with the nucleus, according to circumstances. To be sure the receptors possess no reasoning powers in discriminating against certain substances but merely accept that substance which possesses atomic groups for which they have a chemical affinity and they are indifferent to all others.

A simple outline of the theory may be found in the article entitled "Chemical War on Disease," beginning on page 503. While there has been much criticism of the theory, it appears to account for most of the complicated phenomena involved and furnishes us with a working hypothesis. It enables us to visualize probable conditions that are beyond the reach of the microscope and it gives us a most fascinating picture of the war which the modern chemist wages within the very body of man.

SEAPLANE FOREST PATROL

IMMEDIATELY after the World War, when efforts were made to find peace-time uses for the airplane, it was suggested that the flying machine would prove of value in patroling our great forest reserves to detect the first evidences of fire and thus guard against widespread destruction of valuable timber lands. The airplane was tried out over our western forest and proved a very valuable ally to the fire patrol.

A similar flying patrol was instituted by a company owning large timber lands in Quebec, but in this case instead of airplanes, *flying boats* were employed. This seems like a strange vehicle for use over land until we learn that of the area which covers 160 by 270 miles, about seven per cent is water. Numerous lakes are widely distributed throughout the tract, and they furnish excellent landing places for the seaplane, should they have to come to earth owing to any mishap. Flying at an altitude of five thousand feet they are always within gliding reach of one of these bodies of water. The forest reserve is of such an extent that it takes between two and three years for logs from certain remote regions to reach the mill. This is due to the fact that a portion of the reserve is on a slope that drains into Hudson Bay. The winged patrols have a bird'seye view of from forty to eighty miles and can rush fire fighters to any point in a minimum of time.

An interesting description of this air service may be found in the May issue of *American Forestry*.

The seaplane patrol is maintained not only for the purpose of detecting fires, but also to explore the tract and determine the character of the timber. Photographs are taken from the seaplane and it is possible to tell from the nature of the surface whether the timber is of soft wood or hard wood. The crowns of soft wood are round and give the effect of depth, while the tops of hard wood are irregular and flatter. The camera merely shows the distribution of hard and soft woods but does not give any clue as to the species of the woods. This, however, may be determined visually. The practice is to take a series of photographs and then go over the ground again with an experienced woodsman who can tell from the color and general appearance what species of timber are. He also fills in any parts that are not clearly revealed in the photograph. In this way it is possible to map the tract and its resources very accurately.

Seaplanes have also proved valuable in familiarizing logging bosses with the regions in which they are to operate and they have also been used to take company officials over various territories. A recent expedition of 850 miles was made in 12½ hours. This included a number of stops for closer inspection and one stop for the taking on of fresh fuel. Incidentally the seaplanes are equipped with Liberty motors which were left in Halifax by American forces and these engines have proved remarkably reliable.

Planetary Motions and the Einstein Theories

A Possible Alternative to the Relativity Doctrines That Would Save the Newtonian Law

By Charles Lane Poor

Professor of Celestial Mechanics, Columbia University

THE entire Einstein theory of the universe is based upon two or three pure assumptions as to the fundamental constitution of nature. These are so broad and general in character that they cannot be directly tested. But, if they are provisionally accepted as true, it is possible to build upon them a complete and logical theory of the universe and of the laws governing the motions of all the bodies therein. This Einstein has done with great technical skill, with results that are remarkable and, to say the least, very startling to our preconceived ideas of space and time. It is through these results, through the logical deductions and formulas derived from his postulates, that the hypotheses themselves can be tested.

In order, however, to establish the Einstein theories it will not be sufficient to show that the facts of nature can be explained by the Einstein formulas; it must be conclusively shown that no other hypothesis will equally well explain the observed phenomena. In the words of the mathematician, it is essential for the followers of Einstein to show that his hypotheses and formulas are *necessary and sufficient*.

For many years the Newtonian law as applied by mathematicians has failed to account accurately for the motions of Mercury, and this failure has been made the basis of many attacks upon the Newtonian law, of which Einstein's is merely the latest and best executed. The orbit, or path, of any planet, such as Mercury, about the sun is an immense oval, or ellipse, one diameter of which is longer than the others. This diameter is known as the axis of the orbit. Now, if Mercury were the sole planet in the system, then, under the Newtonian law, this axis would remain fixed in direction; but, under the Einstein law, it would rotate slowly at the rate of 43″ of arc per century. Under such conditions a clear cut issue would be presented, and observations could at once decide between the two theories. Mercury, however, is not the only planet, and the action of the earth and the other planets upon him causes a similar and a much larger rotation of the axis, the exact amount of which can be found only after long and complicated computations. These calculations give 537″ per century and, if the Newtonian law be exact and the *computations correct in every particular*, the axis of Mercury's orbit should rotate by this amount. Direct measurements upon the positions of the planet in the heavens, however, show this rotation to be 579″, or an excess of 42″ over the amount yet accounted for by the Newtonian law, and in extremely close accord with the rate of motion predicted by the Einstein formulas.

At first sight this striking agreement of figures appears to confirm the Einstein theories in a brilliant manner. But, striking as these figures are, the confirmation is not complete, for it is possible to explain the motion of Mercury in full accord with the Newtonian law and in accordance with accepted scientific facts.

The whole matter depends upon the calculations through which the figure 537″ was found. Now it is well known to every mathematical astronomer that these calculations are not complete, that they do not take fully and completely into account all of the bodies of the solar system. In the theories and formulas upon which these calculations depend the sun has been considered as a perfect sphere and all space between the sun and the various planets as free from all gravitational matter. These are necessary mathematical simplifications: Without them the equations of motion would be impossible of solution. These simplifications approximate very closely to the truth and the results obtained by their use very closely represent the motions of the planets, but they are *approximations* and it necessarily follows that the results do not represent the actual motions with complete accuracy.

Every photograph taken, every measurement made of the sun and the various planets show that these assumptions, upon which the simplifications are based, are not true. Neither the sun nor any one of the planets is a perfect sphere. The polar axis of the earth is considerably shorter than the equatorial; a glance through any telescope shows Jupiter to be decidedly elliptical. The sun-spots, which can be seen with an ordinary small telescope, show that the sun is not of uniform shape and density. Exact measurements of the shape of the sun are extremely difficult to make, yet every series of measures, heretofore made, show distinct departure from a true spherical form.

Passing outward from the sun itself one finds the corona. At times of eclipse this halo, or brilliant crown about the sun, can be seen by the unaided eye. It has been sketched many times, it has been photographed times without number. Its presence proves the sun to be surrounded by an envelop of matter of irregular shape and of vast size. This envelop is in general lens-shaped and it extends far out beyond the orbit of the earth.

The exact size, shape and constitution of this envelop is not known; its density is extremely small and the total amount of matter contained in it cannot be very large. It is known, however, that it is not a true gaseous atmosphere of the sun like that of the earth. It consists, in the main, of widely scattered, minute solid particles, each traveling about the sun in its own independent orbit. Some of these bodies may be as small as pin-heads, others many feet in diameter. The zodiacal light is recognized as mainly sun-light reflected from such minute bodies, each too small to be seen separately, but, as a group or mass, reflecting enough light to show as a faint glow against the dark sky.

While matter is thus known to exist in the vicinity of the sun and the inner planets, its effect upon the motions of these planets cannot be absolutely calculated until its distribution is fully known. It is clear that the figure 537″ per century does not accurately represent the motion of Mercury's perihelion under the Newtonian law; but, in the present state of our knowledge of the solar envelop, it is impossible to correct definitely this figure and to state what the final value should be.

Further, the discordance in the motion of Mercury is only one out of eight or ten similar discrepancies in the motions of the planets. Einstein and his followers have stressed the supposed explanation, under his theories, of the motion of Mercury, but have glossed over the necessity of finding an explanation for the remaining discrepancies. Now the theories and formulas of Einstein account partially for one or two of these other difficulties, completely fail to account in the slightest way for others, and finally greatly increase the discordance in the case of Venus. In fact, in the case of this planet, the Einstein formulas would give the orbit a rotation in the opposite direction to that which is required to fit the observations.

According to Newcomb the secular motions of the elements of the four inner planets, as observed and as computed, are as given in Table I. The column of differences contains the unexplained portions of the motions of the planets. That is, in one century the perihelion of Mercury moves 41.6″ of arc more than can be accounted for, while that of Venus does not move quite so swiftly as the computations would lead one to expect. These unexplained portions of the motions are the so-called "discordances" or "discrepancies." That of the peri-

helion of Mercury is especially well known and has figured prominently in many attempts to prove false the law of Newton. The perihelion of Mars shows a large discrepancy, as do also the nodes of both Mercury and Venus.

In the column of differences, after each discordance, is given the "probable error" as determined by Newcomb. While these may give some idea as to the relative accuracy of the various determinations, it must be remembered that the assignment of these probable errors is very largely a matter of judgment, and that the values may have been over or under estimated. In

TABLE I.

	Obsd.	Compt.	Diff.	Plus or Minus	P.C.
PERIHELIA:					
Mercury.....	+ 579.2″	+ 537.6″	+41.6″	1.4″	+ 7.2
Venus.....	+ 42.4	+ 49.7	— 7.3	22.3	—17.2
Earth.....	+1161.5	+1155.6	+ 5.9	5.6	+ 0.5
Mars.....	+1605.9	+1597.8	+ 8.1	2.6	+ 0.5
INCLINATIONS:					
Mercury.....	+ 7.14″	+ 6.76″	+0.38″	0.54″	+ 5.3
Venus.....	+ 3.87	+ 3.49	+0.38	0.32	+ 9.8
Mars.....	— 2.26	— 2.25	—0.01	0.14	— 0.4
NODES:					
Mercury.....	— 753.0″	— 758.1″	+ 5.1″	2.8″	+ 6.8
Venus.....	—1780.7	—1790.9	+10.2	2.0	+ 0.6
Mars.....	—2248.9	—2249.8	+ 0.9	4.6	+ 0.0

every step of the long and complicated computations and reductions, an estimate, rather than an exact calculation, has to be made as to the value of the probable error, and the final value, as given in the table, thus depends upon many separate estimations or judgments. But, taking these probable errors as given by Newcomb, it will be noted that out of the ten differences six are larger than the corresponding probable errors, and of these six, three stand out prominently: The perihelion of Mercury, the perihelion of Mars, and the node of Venus.

The final column in the table gives the percentage that the discordance bears to the observed motion. While this is rather an unusual way of comparing results, it may be of interest and may throw some light on the problem. It will be noted that five of the differences represent very large percentages of the observed quantities, and of these five, three are among the six that exceed their probable errors. These three are in the motions of the perihelion of Mercury, the inclination of Venus, and the node of Mercury.

The discordance in the perihelion of Venus is peculiar. It amounts to over 17 per cent of the entire observed motion, and yet it is only one-third of the apparent probable error. It would seem that where the percentage is so large, the discordance must be real, and that the value of the probable error has been overestimated.

According to the Einstein theory, as noted above, the perihelia of the planets would rotate by various amounts depending upon their respective distances from the sun. This Einstein rotation is independent of the mutual action of the planets upon one another, and in order to find the total motions under the Einstein theories, it should be added to the computed motions as given in the above table. This is shown in Table II, which also gives the final outstanding differences between theory and observation, as based upon the Einstein theory.

TABLE II (Perihelia)

	Newtonian Computation	Einstein	Total	Diff.	P.C.
Mercury...	537.6″	42.9″	580.5″	— 1.3″	0.2
Venus.....	49.7	8.6	58.3	—15.9	37.5
Earth.....	1155.6	3.8	1159.4	2.1	0.2
Mars.....	1597.8	1.3	1599.1	6.8	0.4

Thus the Einstein motion is sufficient to account for practically all the discrepancy in the case of Mercury and to reduce in a marked manner that in the case of the Earth. It accounts, however, for a very small part of the discordance in the case of Mars, and more than doubles the already large discrepancy in the motion of Venus. Further the Einstein law does not in any way account for the important discrepancies in the motions of the nodes and in the inclinations of the planets.

Turning now to the matter which is known to exist in the vicinity of the sun and planets, while as we have said we cannot determine its quantity and general distribution, it is perfectly possible and reasonably easy to find what distribution of this matter would under the Newtonian law, give a motion of 42″ to Mercury's perihelion, and thus make the total motion 579″, as required by observation. This problem is similar to that solved by Adams and Leverrier, which resulted in the discovery of the planet Neptune. Moreover, it is then found that the distribution that will explain the motion of Mercury will fully explain that of the other planets; it will give the orbit of Venus the necessary rotation, both in direction and in amount. What the Einstein formulas fail to explain, the presence of a great lens of matter about the sun explains fully and satisfactorily.

The quantity of matter required in the solar lens for this purpose, and the distribution which it becomes necessary to assign to it, are entirely within the limits of reason. The matter in the immediate vicinity of the sun would tend to group itself about a plane somewhere near that of the solar equator, or that of the orbit of Mercury; while matter at a considerable distance from the sun would tend more toward the invariable plane of the solar system, which is nearly the same as that of the orbit of Jupiter. Further the density of the matter will decrease as the distance from the sun increases. This general distribution can be approximated by assuming the whole mass to be made up of ellipsoids of revolution, each ellipsoid of uniform density, but the larger ones of much less density than the inner ones. Some such assumption is necessary to reduce the problem to the realm of figures; the selection of ellipsoids of revolution is naturally indicated by the fact that all the known bodies of the solar system are such ellipsoids.

For purposes of computation the mass may be supposed to be made up of superimposed ellipsoids, each of constant density. This merely makes the changes in density abrupt, instead of gradual. Three such ellipsoids are necessary and sufficient to account for the motions of the perihelia of the four planets:

a. A small central ellipsoid entirely within the orbit of Mercury, and embracing only the matter in the immediate vicinity of the sun. The position of this ellipsoid in space was determined from equations of condition derived from the discordances.

b. An intermediate ellipsoid entirely within the orbit of the earth, but extending beyond the orbit of Venus. The principal plane of this ellipsoid was assumed as being the same as that of the orbit of Jupiter.

c. An outer ellipsoid entirely within the orbit of Mars, but extending beyond the orbit of the earth. The principal plane of this ellipsoid was assumed as being the same as that of the orbit of Jupiter.

The mass, or density, of each ellipsoid is a function of its radius and cannot be independently determined. The radii can, however, be assumed arbitrarily and the corresponding masses and densities found. With an assumed ellipticity of 0.9 and assumed radii we have:

	Assumed radii	Corresponding densities
Inner ellipsoid	0.05	1.2×10^{-7}
Medium ellipsoid	0.98	1.7×10^{-13}
Outer ellipsoid	1.36	7.4×10^{-14}

where the density of the sun is unity. If the inner ellipsoid be assumed to be of larger radius, then its density would be correspondingly less.

With the assumptions thus outlined, the motions of the planets were calculated. The results appear in Table III on the following page:

The relative probabilities of two solutions of a problem are usually determined from the final differences or residuals, as these differences are called. That solution is deemed the most

probable which makes the sum of the squares of the residuals the smaller. If this test be applied to the residuals obtained in Table II with the Einstein theory as the basis and to those from Table III, the results are:

Einstein theory	438.38
Solar envelop	14.07

And these clearly indicate how very much more probable is the explanation of the motions of the planets as due to the presence of matter in space, than by the hypotheses of Einstein.

TABLE III

	Motion due to Solar Envelop	Total Motion	Final Diff.
PERIHELIA:			
Mercury	+41.6″	+ 579.2″	0.0″
Venus	— 7.5	+ 42.2	+0.2
Earth	+ 5.9	+1161.5	0.0
Mars	+ 6.9	+1604.7	+1.2
INCLINATIONS:			
Mercury	+0.37″	+ 7.13″	+0.01″
Venus	+0.45	+ 3.94	—0.07
Mars	+0.12	— 2.13	+0.12
NODES:			
Mercury	+ 4.9″	— 753.2″	—0.2″
Venus	+ 9.1	—1781.8	—1.1
Mars	+ 4.3	—2245.5	—3.4

Einstein and his followers have cited the motions of the planets as conclusive proof of the truth of his hypotheses. The evidence does not sustain this—his hypotheses and formulas are neither *sufficient* nor *necessary* to explain the discordances in these motions. They are not *sufficient*, for they account for only one among the numerous discordances—that of the perihelion of Mercury; they are not *necessary*, for all the discordances, including that of Mercury, can readily be accounted for by the action, under the Newtonian law, of matter known to be in the immediate vicinity of the sun and the planets.

Thus the motions of the planets do not prove the *truth* of the Einstein theory, nor, on the other hand, do they prove its *falsity*. While these motions can be accounted for by a certain distribution of matter in the solar envelop, it has not yet been established by observation that the matter is distributed through space in the required way. In the present state of our knowledge regarding this matter, the motions of the planets do not and cannot furnish a definite answer to the question as to the validity of either hypothesis. It is then a problem of observational astronomy to investigate the actual distribution and density of the matter in the solar lens, and to determine whether or not it approximates the conditions necessary to account for the planetary motions. In 1908-10, before Einstein had developed his astronomical theories, I called attention to the desirability of doing this; but the astronomical world could not see the need of the investigation and it was never made.

NEW OBSERVATIONS ON THE VARIABILITY OF THE SUN

(*a*) SIMULTANEOUS spectro-bolometric observations of the solar constant of radiation in California and Algeria in 1911 and 1912, and in California and Chile in 1918, (*b*) comparisons of the distribution of radiation over the sun's disk with simultaneous measurements of the intensity of total solar radiation, (*c*) comparisons of the temperature of the earth with the radiation of the sun, and (*d*) several other minor evidences, have all indicated a short irregular periodicity in the sun's omission. In other words, the sun appears to be a variable star ranging through about 0.10 stellar magnitude between extremes and often changing 0.03 magnitude within a few days.

For about six years the intensity of solar radiation has almost always exceeded the mean value, 1.933 calories per square centimeter per minute, which was found from the Washington, Mt. Vernon and Mt. Whitney observations of 1902-1912, as published in Vol. 111 of the Annals of the Astrophysical Observatory. This condition of affairs was expected to attend the return of increased solar activity, otherwise evidenced by numerous sunspots, prominences, faculæ. We have now, however, long passed the period of maximum sunspots, so that we should naturally expect the sun's radiation to be falling below the mean value of 1902-1912. The results obtained by the Smithsonian observers at Calama, Chile, indicate quite otherwise.

I have computed solar radiation values for each five days' interval from July 1, 1919, to March 25, 1920. The mean value is never based on less than two observations, and this minimum occurs only in two instances. All other values depend on three days of observation, more often four, and very often five.

One is immediately struck by the wide fluctuation of the mean values shown. The fluctuation of individual days naturally had a still wider range, reaching in fact to 8 per cent. The mean values cover a range of 5 per cent. With gradually diminishing swings, up and down, the radiation fell from June, 1919, to early in October, then suddenly leaped up to a high mean value which it maintained until early in December, and then again suddenly leaped much further and remained from the end of December to the middle of March, 1920, at a mean value far in excess of anythings which we have any record of, continued for so long a time as three months during the whole fifteen years in which solar constant observations have been carried on with anything like regularity. Toward the end of March an extremely rapid fall of radiation occurred so that individual values have run as low as 1.86 calories.

In view of this extraordinary march of solar radiation values, it may be recalled that we passed through an exceptionally cold and cloudy winter from about the first of December, 1919. The cloudiness prevailed in South America as well as here, so that if it had not been for the introduction of the new method of observing, of which notice was given to the Academy at its last meeting, the observers would not have been able to give us this very continuous record.

At first sight it looks paradoxical that a cold winter could accompany extraordinarily high values of solar radiation, but it has been not only a cold winter, but a cloudy winter. Hence it may have been that the direct effect of the outburst of solar activity was to produce excessive cloudiness which by high reflection diminished the radiation available to warm the earth.—Abstract of article by C. G. Abbot, Astrophysical Laboratory, Smithsonian Institution, Washington, in Proceedings of the National Academy of Science for November, 1920.

BENGAL'S DISASTROUS CYCLONE

THE Meteorological Department of the Government of India has issued its report on the administration in 1919-1920. Observations in connection with the upper air have been developed on behalf of the aviators who are from time to time crossing India. Storm warnings for stations in the Bay of Bengal and in the Arabian Sea are said to have been carried out successfully. It is, however, admitted that the warning of the great storm on the night of September 24, 1919, was inadequate. The storm crossed the Bengal coast as a cyclone about noon on September 24. It reached Dacca at about 2:30 A. M. on September 25, and finally broke up on that day in the Assam hills. At the center the deficiency of pressure was about 1¼ inches, and the calm area at least 15 miles in diameter. The total loss of life is estimated at 3,500. The value of property destroyed was probably greater than in any storm in Bengal for the last two hundred years, but the destruction of human life was probably greater in the Bakarganj cyclone of 1876. An additional terror was caused by a vivid red glow appearing in the sky during the period of the lull.—From *Nature* (London), April 28, 1921.

THE EGYPTIAN EXPEDITION OF THE METROPOLITAN MUSEUM OF ART, 1918-1920, BRINGING ITS FINDS TO A PLACE OF SAFETY

Egyptian Life Four Thousand Years Ago

How the Most Famous Noah's Ark in the World Came to the Metropolitan Museum of Art

(Photographs by courtesy of the American Museum of Art.)

IN the SCIENTIFIC AMERICAN for May 7th, there was published a brief article entitled "Looking Backward 4,000 Years," and now through the courtesy of the Metropolitan Museum of Art, we are enabled to publish a number of additional pictures and in lieu of the conventional article on the subject, we have decided to use the exact words of two members of the Expedition, Messrs. Lansing and Winlock, the latter being in direct charge of the Expedition. Their narratives bristle with interest and suggest "Captain Kidd" or "Treasure Island," but the best of it all is that it is *real* and one-half of the "find" is in the sixth room of the Egyptian Department in the great musuem on Fifth Avenue.

"In the course of the work of the Egyptian Expedition of the Metropolitan Museum of Art on its concession on the west bank at Thebes, our attention had been drawn," says Mr. Ambrose Lansing, "to that part of the site south of Deir el Bahri, among the spurs and cliffs of the mountain which separates the Valley of the Kings from the plain. Here, during the troublous times in Egypt, a good deal of plundering had been going on, and in forestalling some of this unauthorized digging I had been fortunate enough to find the burial-place of a young prince of the Eighteenth Dynasty, who had been torn to pieces by ancient tomb robbers in their search for gold, and had then been reburied by the priests of the Twenty-first Dynasty. The tomb had been in an almost inaccessible cranny of the cliff wall, and similar clefts in the rock face looked as if they too might contain hidden tombs.

"At the beginning of the season of 1919-1920, these were thoroughly cleared, but not a trace of occupation was found. A huge tomb of the Eleventh Dynasty—from its size and position evidently that of a high offcial [The noble—he was a prince and chancellor of the kingdom about 2,000 B.C., by name Mehenkwetre (an Egyptian equivalent of Heliodorus).] of the last of the Mentuhoteps—looked as if it might give us a chance of recouping our fortunes. Mr. H. E. Winlock, who was in charge of the excavation, looked it up and found that work had been done on it in 1895 by Daressy, and that he had found fragments of finely painted relief there. We could see that the clearing of the forecourt at least had not been thoroughly done, and it was there that the sculpture had been found. Mr. Winlock finally decided that it was as good a chance as any, and the men were set to work there.

"A very few days' work with a big gang of workmen laid bare the platform which had been the forecourt of the tomb. It had originally been in the form of a portico, and the walls had been built of fine imported limestone sculptured in low relief, and painted with a delicacy rarely equaled in Egyptian art. But of this only a few fragments were found, none of them as much as six inches square, and they only resulted in making our disappointment the keener. Two mauls, so rough that, if found in other circumstances, they would have been taken for Palæolithic implements, suggested the ruthless manner in which the ancient quarrymen had broken up the sculptured blocks for building-stone.

"So our hopes were dashed again. In order to get an adequate plan of the tomb, it was necessary to clear the corridors and the two burial shafts. We were sure that we should get nothing in the way of antiquities in doing this, for the previous excavator had evidently dug them thoroughly, and the débris appeared to be nothing but stone fallen from the walls and ceiling. Still a good plan is better than nothing, and is always of interest to the archæologist, if not to the layman. So, as it is our practice always to clear and plan thoroughly, we felt obliged to do so in this case. Conscientiousness was rewarded.

"In clearing the fallen rock from the main corridor, a workman dislodged a loose stone from the side near the floor, and the small chips began trickling into a small dark hole. It was the evening of March 17. Mr. Burton was in charge of the work, and was called by the excited foreman. The hole was small, and the passage dark, and even matches helped little to show what was hidden within. A hurriedly written note brought Mr. Winlock and myself up from the house with an electric torch. Each of us in turn glued his eye and the torch to the hole in the rock. None of us expect ever again to have such a sight appear to us. 'The beam of light shot into a little world of four thousand years ago, and I was gazing down into the midst of a myriad of brightly painted little men

WHAT WAS SEEN THROUGH A CRACK IN THE ROCK

The world of 4,000 years ago in brightly painted miniature as revealed by the electric torch. The girl still poised her basket of meats and stared stonily at the invader

going this way and that. A tall, slender girl gazed across at me perfectly composed; a gang of little men with sticks in their upraised hands drove spotted oxen; rowers tugged at their oars on a fleet of boats, while one ship seemed foundering right in front of me, with its bow balanced precariously in the air. And all of this busy going and coming was in uncanny silence.'

"It was too late to do anything except to seal up the crack, set a guard for the night, and speculate till late on what we thought we had seen, and what the morning would bring to light. The next three days were the busiest of our several careers. To clear that small chamber of its contents before the change of air loosened the friable shale of the ceiling, and yet not to remove the different objects before all the evidence was recorded and the necessary photographs taken, was a job requiring hard work and nice judgment. But it was done; and just in time, for, soon after we had everything out, the stones began to fall."

Mr. Winlock continues this interesting narrative as follows:

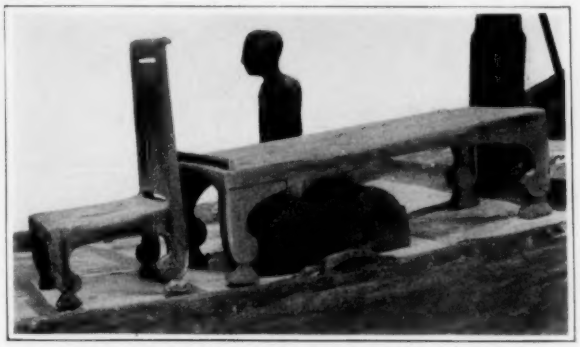
"As we worked along through those three days and nights we began to realize what it was that we had so unexpectedly discovered. The tomb was that of a great noble of four thousand years ago. He himself had been buried in a gilded coffin and a sarcophagus of stone in a mortuary chamber deep down under the back of the corridor, where the thieves had destroyed everything ages before our day. Only this little chamber had escaped, and it was turning out to be a sort of secret closet where the provision was stored for the future life of the great man.

"He could not conceive of an existence in which he would not require food and drink, clothing and housing, such as he was used to in this life; and, being a rich man, naturally he wanted an estate in eternity like that which he had owned on earth. His philosophy carried him beyond that of the savage chieftain who expects a horde of servants to be slaughtered at his grave. He attained the same end by putting in his tomb a host of little wooden servants, carved and painted, at their daily tasks, working before little portraits of himself. The spirits of these little servants worked eternally, turning out spirit food or sailing ships upon a spirit Nile, and his soul could enter any one of the little portraits of himself at will to reap the harvest of their labors. In short, we had found a picture of the life the great noble hoped to live in eternity, which was nothing more or less than the one he had led on earth forty centuries ago.

"The first thing we had seen when we had peeped through the cack had been a big model nearly six feet long, showing the noble seated on a porch among his scribes, taking the count of his cattle as they were driven past. In the back of the room we found, under a lot of other models, neatly stacked, the stable where these same cattle were being fattened, and finally when we came to move one big box-like affair in the far corner—a model I had tried my best to get a peep into and almost fallen headlong in the process—we found it was the butcher-shop where the cattle's life history ended. The night we worked in the tomb by lamp-light we got a peep into a granary where diminutive scribes sat writing down the quantity of grain being measured and carried to the bins by hard-working laborers. And later we ran across the bakery where the grain was ground and made into loaves, and the brewery where the home beverage was being fermented in tall crocks and then decanted into round-bellied jugs. Mr. Lansing extricated two canoes manned by fishermen, who hauled a miraculous draft of painted wooden catfish and perch in a seine; and I picked the fallen stones out of two gardens in which copper ponds—that would hold real water—were surrounded by little

wooden fig-trees and cool, shady porches. Then there was a carpenter-shop, and another shop where women spun thread and wove cloth. The very threads on their distaffs and spindles—frail as cobwebs though they were with age, had remained unbroken in that eternal stillness.

"Thus had the great man lived, and so did he expect to live after he had gone to his 'eternal abode,' as he called it. Finally, the funeral day had come. His body was brought across the river from his mortal home in Thebes, through the green fields where the wondering peasants leaned on their hoes to watch it pass, and then up through the rocky gorges to his tomb. A long procession followed him, each model borne on the head of one of his serfs, and a crowd of peasant girls and women from his estates brought baskets of wine and beer and baked meats for the funeral banquet. Even their contributions were expected to go on for ever, and statues of two of them, half life-sized, had been made to go with the models in the chamber. There we found them, towering above the horde of miniature men and beasts, looking over at us with grave, wide-open eyes. Four thousand years they had stood thus silent.



STEWARD GUARDING TRUNKS UNDER A BERTH IN A MINIATURE BOAT

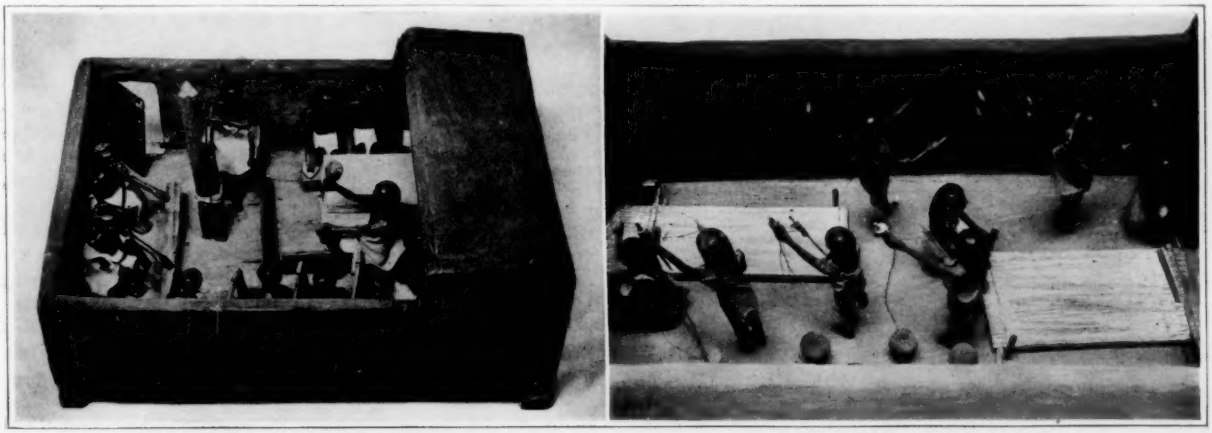
"Four thousand years is an eternity. Just saying it over and over again gives no conception of the ages that have gone by since that funeral. Stop and think of how far off William the Conqueror seems. That takes you only a quarter of the way back. Julius Cæsar takes you half-way back. With Saul and David you are three-fourths of the way, but there remain another thousand years to bridge with your imagination. Yet in that dry, still, dark little chamber those boats and statues had stood indifferent to all that went on in the outer world, as ancient in the days of Cæsar as Cæsar is to us, but so little changed that even the finger-prints of the men who put them there were still fresh upon them. Not only finger-prints, but even fly-specks, cobwebs, and dead spiders remained from the time when these models were stored in some empty room in the noble's house waiting for his day of death and burial. I even suspect that some of his grandchildren had sneaked in and played with them while they were at that house in ancient Thebes, for some of them were broken in a way that is hard to explain otherwise. Possibly that is a wild guess, but at any rate there is no doubt of what had happened to them in the little chamber in the tomb on the day of the funeral. After all of the models had been stowed away and the masons had come to brick up the doorway, they had found one of the boats in their way. So one of them picked it up and laid it to one side on top of the granary, and under bow and stern he left a great smear of the mud he had just been mixing for mortar. There those smears still remain.

"The little models had to be parted after all these ages together. Half of them went to the Egyptian government under the terms of our concession, and are now on view in the museum in Cairo. The others can be seen in the Metropolitan Museum in New York."

Mr. Winlock continues in a monograph published by the Museum.

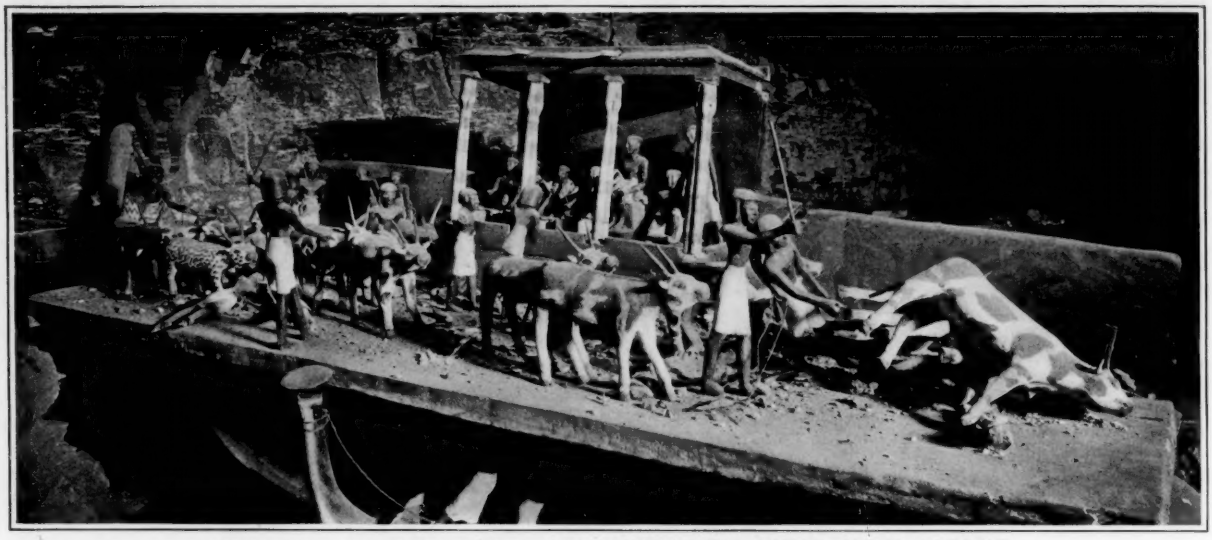
"Only three of the models have anything to do with the tomb or with the funeral. On either side of the chamber stood the statues of two girls dressed in fancifully colored garments, bringing offerings to the tomb—one with a basket of wine jugs and the other with a basket of meats and breads upon her head, and each with a live duck in her hand. They are carved of wood, half-life-size and practically as perfect as the day they were made. Another little group of four figures on a single pedestal represents a priest bringing his censer and libation vase; a man with a pile of bed linen upon his head; and two more girls carrying geese and baskets of food.

"All of the rest of the models pictured the life which Mehenkwetre had lived in this world and the one he expected in the next. Largest and most imposing of all was a model showing the noble at the counting of his cattle. The scene is laid in the courtyard before his house, overlooked by a porch with four brightly colored columns in front. Here he sits with his son and heir squatting on the floor on one side, and four clerks on the other, each busily recording the count on a papyrus roll. On the porch and on the steps stand his butlers and stewards and in the courtyard facing the porch the chief herdsman bows and salutes his lord as he reports. In front there is a waving of sticks and arms as the other herdsmen lead and drive past the beeves—red, black, piebald and speckled. The carving of the little figures, averaging about eight or nine inches high, can scarcely be said to be on a high artistic plane, but there is truth and observation, movements are correctly caught, and with all the brilliancy of the colors there is a cheerfulness that more formal Egyptian works lack.



CARPENTRY IN ANCIENT EGYPT

MILL LASSIES ON THE NILE



MEHENKWETRE, AN EGYPTIAN NOBLE, COUNTING HIS CATTLE—MODEL AS FOUND

"Next in the life history of the ox is the stable where he is fattened. In one room the stall-fed beeves are lined up at the manger; in the other the already fat animals are being fed by hand and one has so nearly got to his limit that he lies upon the floor while a cowherd stuffs food into his mouth. Finally comes the last scene in the slaughter-house. The beeves have been led into a columned hall, two stories high and open to the air high up on one side. They are thrown on the ground and trussed up for butchering; a scribe with pen case and papyrus roll is present to keep the accounts; a head butcher superintends the killing and two men make blood puddings over braziers in the corner. On a balcony at the back the joints of beef 'hang' on lines to ripen.

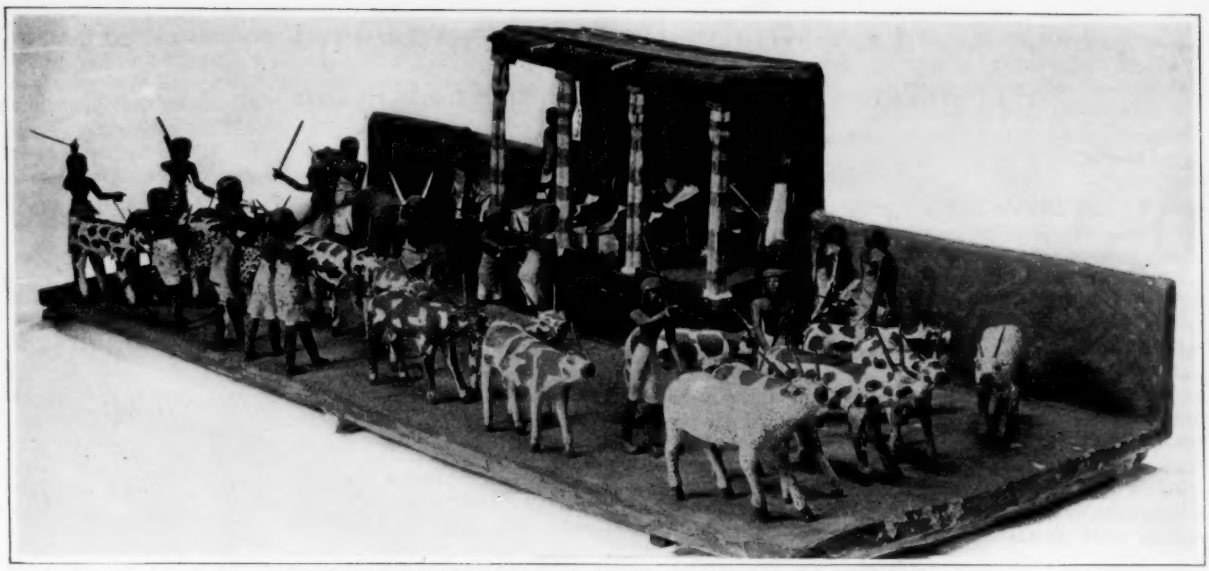
"The meat supplied, grain foods are next shown. At the granary the ever-present clerks sit in the courtyard with papyrus rolls and tablets keeping the account while two men scoop up the wheat in measures and load it into sacks, and others carry it up the stairs to dump it into three capacious bins. By the front door there sits a boss with cane in hand superintending the work and watching that no one leaves before the time is up. Then cames the bakery and brewery combined in one building. In the first room two women grind the corn into flour and a man makes it into cakes of dough, which another treads into a mash in a barrel. Near by, the rising mash stands in four tall crocks while the yeast ferments, and when it has finished working, another man pours it into a row of stoppered jugs which stand long the wall. In the other room is the bakery. Men are cracking the grain with pestles; women grind the flour; men mix the dough and make fancifully shaped loaves and cakes, which others bake in ovens.

"Handicrafts take up two models. The women spin and weave in one shop and the carpenters ply their trade in another. In the weaving shop three women prepare the flax and put it into buckets for three others who spin it, standing with their distaffs in their left hands and turning their spindles with their right hands against their knees. When the spindles are full they cross to the opposite side of the shop to stretch the newly spun thread out on three pegs on the wall. Meanwhile other women weave cloth on two looms stretched out on the floor. The carpenters' shop is a half-roofed-over court with a furnace for sharpening tools and a tremendous tool chest full of saws, adzes, chisels, and drills beneath the shed. Around the sides of the open court squat gangs of carpenters squaring great timbers with adzes and smooth-surfacing them with blocks of standstone. In the middle of the court a sawyer has lashed a balk of timber upright to a post while he hip-saws it down into boards and another carpenter sits astride of a plank cutting mortise holes in the edge with mortising chisel and mallet.

"Two model gardens were provided for the soul of the great man—models which, so far as our experience of Egyptian antiquities goes, are unique. Just as when we make a child's doll house we leave out lots of details like stairways and put all of our attention on the more important and showy rooms, so the ancient model-maker has devoted all his pains to show only those parts of the house and garden which would most delight the heart of his patron. There is the high wall which shuts out the outside world. Within, a little oblong pool—of copper so that it will hold real water—is surrounded by fruit trees, and facing it is a cool deep porch with gaily painted columns. At the back of the porch a great double state-doorway with a fanlight above, a smaller door for every-day use, and a tall latticed window give a semblance of the façade of the house itself. The trees, made of wood with each little leaf carved and pegged in place, are typical of the naïve realism of all of the models. The fruit is shown, not growing from the twigs but from the main stems and branches so that there shall be no doubt but that the sycamore fig is intended.

"A great man like Mehenkwetre would be required to journey up and down the river to administer his scattered estates and to fulfil his duties in the king's administration. Travel, as always in Egypt, was wholly by boat and a man of high rank would have owned his own vessels for travel and others for pleasure, for the river and the marshes were the playgrounds of the Egyptians. Half the models we found, therefore, are ships and boats to fulfil the needs of Mehenkwetre in a future state which was to be but a repetition of his mortal life. He lived a generation or two before the new cult came into Upper Egypt which required a man to prepare a mystic barge to accompany the Sun on its journeys and it is doubtful whether he even intended any of these boats to represent his funeral float. They are, in fact, models of the every-day ships which plied up and down the river four thousand years ago.

"There are four traveling boats—thirty or forty-footers supposedly, but in the models about four feet long—with crews of from twelve to eighteen sailors besides helmsmen, bowsmen, and captains. Going up river with the prevailing northerly wind, they set a great square sail and we see the little sailors making fast the backstays and hauling on the halyards. Coming down the river with the current against the wind, the mast was lowered in a rest, the sail stowed on the deck, and the crew got out the sweeps. They start their stroke with one foot on the thwart in front and then all together



MODEL OF MEHENKWETRE COUNTING HIS CATTLE—AS RESTORED

heaving on their oars, they end it sitting on the thwarts behind them. On each boat Mehenkwetre sits in his chair at his ease smelling a lotus bud, with his son beside him on one side and a singer on the other patting his mouth with his hand to give his voice a quavering, warbling sound. In one case the singer is accompanied by a blind harper whose harp sits in a little wooden stand between his knees.

"In one cabin sits a stewart as shown in one of our engravings beside a bunk under which are tucked two little round-topped traveling-trunks" [*very much like the old-fashioned "hair trunks" of our great grandfathers.*—EDITOR].

"The river boats of those days were none too large and cooking meals upon them would have been too much of a nuisance for the great man. The kitchen therefore was upon a second boat which followed behind and was moored alongside at meal times. On board women ground flour; men baked—sometimes standing in the dough vat and kneading with their feet while they rolled loaves with their hands; and in the cabins joints of meat were hung up and racks of beer and wine jars were stowed. For shorter trips and pleasure sails there were yachts—long, narrow, green vessels with high curling prows and stems. If the wind was favorable, they stepped the mast and set a square sail like that of the traveling ship. When the wind was contrary, mast and sail were lowered and sixteen members of the crew got out their black, spear-shaped paddles to propel the boat. On these boats there was no room for a sleeping cabin and the master and his son sat on the deck sheltered from the sun under a little canopy.

"For sport there is a little, narrow, light draft skiff for hunting birds and spearing fish in the backwaters. In the bow stand harpooners and the enormous fish struck by one is being landed over the gunwhale. Lashed to the side of the cabin are the poles and stakes for bird nets and a boy and a girl are bringing live ducks which they have caught, to the master and his son who sit on deck. Finally, there are two reed canoes drawing a seine full of fish. Two men paddle each canoe, amidships of which stand the fishermen who haul the net and the helper who lands the fish.

"One great interest of these models is the information they supply on rigging and sailing. In the first place they were originally very complete and accurate and in the second place they are so well preserved that most of them still show ropes and knots intact. For instance, the steering oar can now be studied fully for the first time."

OLD PERSIAN COLONY IN AFRICA

IN the March issue of *Man*, Mr. Ainsworth Dickson describes the only survivals of the regalia of the WaVumba tribe in the delta of the Umba River. They are descendants of a party of Persians who migrated about A.D. 1200 to this district from the plains of Sheraji. About A.D. 1700 the country was swept by a horde of cannibals from the south, and many of the people removed for safety to the adjacent Island of Wassein. The objects now described consist of drums, horns, and cymbals used at the enthronement of a sultan, and with the ruins of a few mosques and some Durbar customs they form the only material evidence of a once-flourishing Persian colony.—Abstracted through *Nature* (London).

A TRAVELING BOAT AND ITS KITCHEN TENDER

SEINE DRAWN BETWEEN TWO CANOES

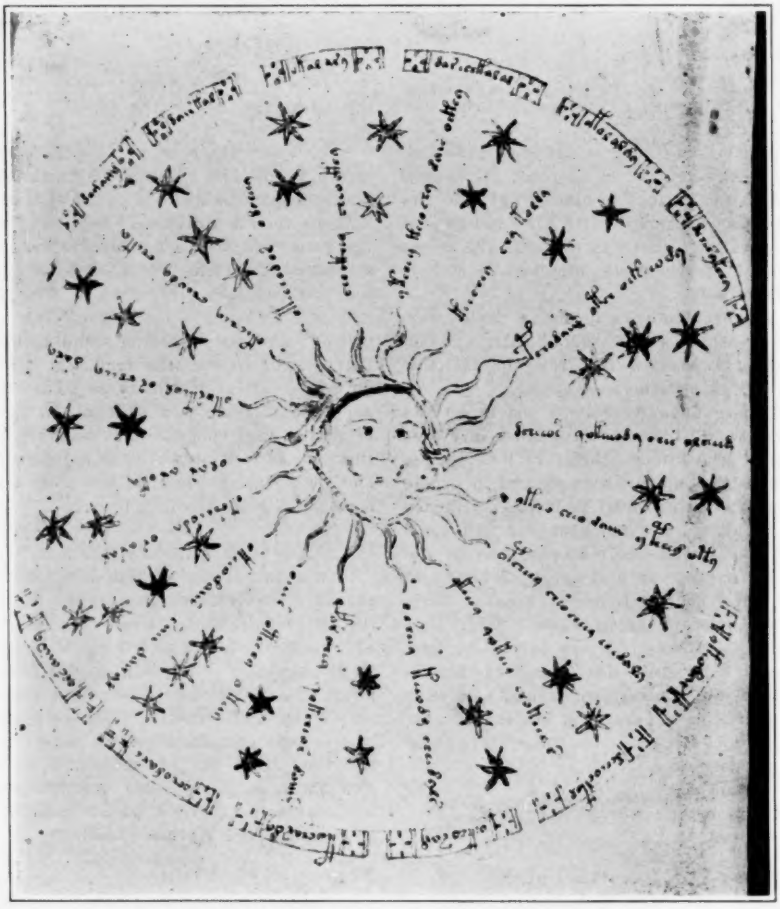
The Roger Bacon Manuscript

Investigations Into Its History, and the Efforts to Decipher It

By J. Malcolm Bird

DURING the year 1912 Mr. Wilfrid Voynich of New York was traveling through Europe in connection with his business of buying and selling old manuscripts. At an old castle somewhere in northern Italy or southern France he located several large chests, containing an unusual quantity of medieval documents, which had been thus preserved from the collection formed in the eighteenth century by the Dukes of Parma, Ferrara and Modena. It appears that these had been hidden away for safe keeping during the political upheavals of the 1700's or early 1800's, and that their presence and even their existence had been completely forgotten until Mr. Voynich came upon them. He bought some of them, and in view of his expectation of some day going back for the rest, he will not tell any more definitely where they are to be found.

Among the manuscripts of the collection Mr. Voynich noted one that interested him exceedingly, and he made sure that it was in the group he brought away with him. His first casual examination of it, prior to its purchase, was sufficient to make him certain that this manuscript was a product of the thirteenth century. The text would seem to the layman to be Latin, with perhaps some quaint chirography to make its reading more difficult; but to one accustomed to the medieval Latin it is clear that the work is in cipher. It was this fact, taken in consideration with the character of the illustrations found in profusion on every page, that impressed Mr. Voynich. Of these illustrations, some are obviously of astronomic or astrological subjects. The rest are strongly suggestive of an effort to illustrate biological processes, both animal and plant, of some sort. It is entirely obvious that the details are masked behind a heavy veil of symbolism, but Mr. Voynich did not have to take too long a leap in reaching the conclusion that the manuscript dealt with scientific or pseudo-scientific subjects.



AN ASTRONOMICAL PAGE NOT YET "TRANSLATED"

Now a cipher manuscript of a scientific nature from the thirteenth century is on its face a matter of great interest. One cannot refrain from speculating on its authorship. Having thus speculated, one is brought almost automatically to a choice between two possibilities.

It seems reasonable enough to suppose that if this cipher really is of a scientific nature, it constitutes an effort of the scribe to make known to succeeding generations knowledge which he had acquired and which it was unsafe to reveal during his own life. No other reasonable motive for the cipher appears; and this motive is not alone a reasonable one, but one which can be thoroughly justified on historic grounds. If we search the annals of the thirteenth century for men capable of scientific investigation of sufficient originality, and sufficiently free from the petrified scholastic model, to lead to new and dangerous truths, we find that the author might have been Roger Bacon, that he might have been Thomas Aquinas — and that he could hardly by any chance have been anybody else.

On geographic grounds, the manuscript having turned up in southern Europe, we should perhaps be inclined to lean toward the possibility of Aquinas having been the scribe. But when we reflect that our knowledge of the ancient Greek literature is for the most part derived from manuscripts that journeyed to Arabia (in some if not in most cases *via* Rome) and thence to Spain, we must realize that it is a mistake to assume that the works of a given scribe will turn up only within a small radius of his seat of operations. And on every ground other than the geographical one, the probabilities fairly screech the name of Bacon over that of Aquinas.

The Englishman was a rebel against the scholastic learning—a rebel to such an extent that he was continually in hot water with the church government. He was a master of cipher, and is known to have thus cloaked some of the things which he wished to keep from the prying eyes of his superiors. Aquinas, on the other hand, was a most devoted exponent of scholasticism, and if profane knowledge had come into his life he would probably have been the first one to suppress it. It is hardly possible to conceive of the Neapolitan as the author of such a work as we have agreed to assume this one to be;

it is almost as difficult to reject the idea that Bacon must have done precisely the thing which we have pictured our unknown scribe as doing. On every ground, the assumption that a thirteen century cipher manuscript of a scientific nature is from his pen is entirely tenable as a working hypothesis.

We cannot allow it to rest as a mere working hypothesis, however; we must exert every endeavor to check it up, to support it as strongly as may be and even to prove it, if this be possible. Such effort will take two directions—the attempt to read the manuscript and thus get either positive testimony or internal evidence with regard to its authorship; and the attempt to trace its history from the time when we picture the scribe as laying it down in Oxford to the time when Mr. Voynich found it somewhere within five hundred miles of the Alps.

For the first of these investigations Mr. Voynich is not qualified, and he has turned the text over to Prof. W. R. Newbold of the University of Pennsylvania. For the business of delving into the certainties, the probabilities and the possibilities of the manuscript's history since its preparation, on the other hand, its owner is about as well equipped as anyone, and to this task he has given his own attention. It is not to be expected that he will be able to produce, for every link of the chain, documentary evidence or other proof that would stand up in a court of law; nevertheless he has made it entirely plausible to suppose that this manuscript may have passed from Oxford to the place where he found it.

A TYPICAL PAGE OF DRAWINGS WHICH ARE SUPPOSED TO BE OF A BIOLOGICAL CHARACTER

Here it is presumed that we have stages in the reproduction of plants from seed.

The first step was easy. Bound in with the leaves of the manuscript is a letter of presentation from Marcus Marci to Athanasius Kircher. It identifies the manuscript, explains the gift on the ground of Kircher's oft-expressed interest in the document, and alludes to previous ownership of the manuscript by the Emperor Rudolf. This of course is a tremendous stroke of luck—the letter might equally well have contained nothing but the name of donor and recipient, and an expression of their mutual regard.

Marci and Kircher are both known figures. Marci had been president of the University of Prag, which to all intents and purposes was the capital of Rudolf's empire, rather than Vienna. For Rudolf was a bookish king, far more interested in literary pursuits than in matters of state; and such pursuits naturally centered in Prag rather than in Vienna. Kircher was a Jesuit scholar of some note, known to have been long intimate with the Parmese ducal family. His established ownership of the manuscript, and its subsequent appearance in the ducal collection, leaves little room for doubt that he made it over to the Duke of his period—perhaps in his will, perhaps during his lifetime.

By another stroke of fortune it became possible to account adequately for Marci's possession of the manuscript. The details of the text, faded as they were with age, were difficult to make out. Photostatic reproduction with long exposures was tried, with the hope that it would act, like astronomical photography, to bring out markings which were not clear enough to make instantaneous impression on the eye, as they must to be seen at all. The effort was successful; and among the things which it revealed was a fragmentary signature on one of the pages, which was identified as that of Jacobus Horcicky de Tepeneez. The proud possessor of all this name was quite a famous botanist, and held the post of director of Rudolf's chemical laboratory. An interesting sidelight which goes to indicate that human nature is substantially constant may be seen in the fact that de Tepeneez accumulated a huge fortune through the sale of eau de cologne as a universal remedy.

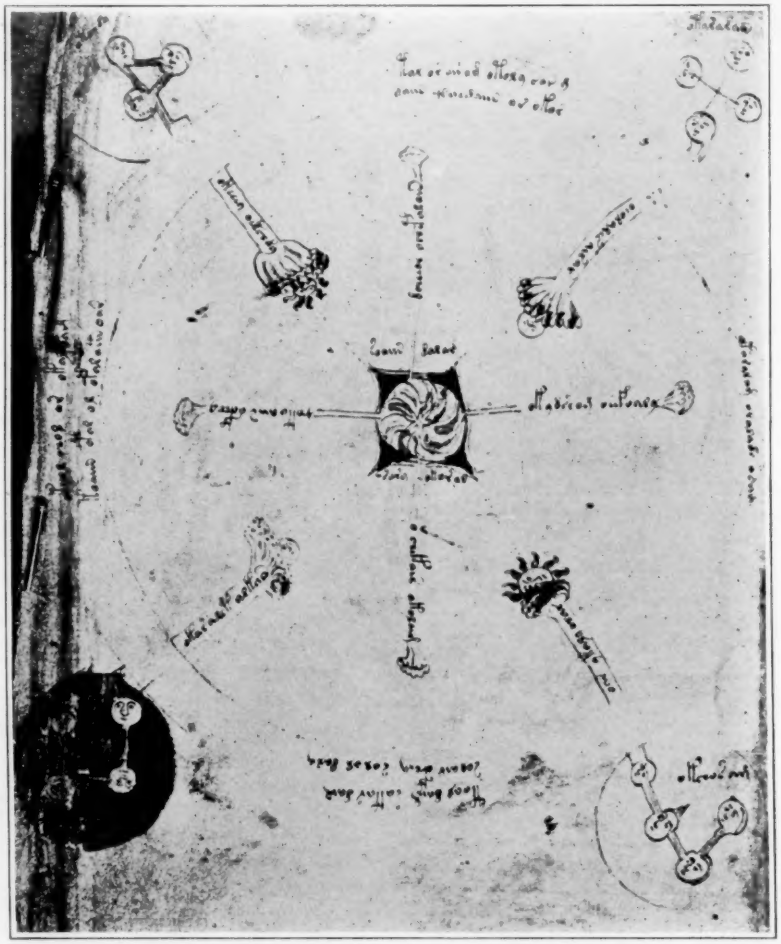
The botanist could hardly have attached his signature to the manuscript unless it had been his property. Independent documentary evidence is available which indicates that the Emperor loaned him the manuscript, not long before his (Rudolf's) death. Mr. Voynich reminds us that after this event the great collection of manuscripts and other scientific material amassed by Rudolf was dispersed, quite informally—which is to say, everybody helped himself to whatever he wanted. The assumption seems a fairly reasonable one that de Tepeneez decided that he wanted the mysterious cipher manuscript worse than anyone else, and made a mental transfer of its ownership from the imperial estate, in which nobody had any particular interest, to himself.

There is no direct evidence indicating where Rudolf got the manuscript, but there is indirect evidence that it is not easy

to reject. One of Rudolf's courtiers in a letter tells us that it was brought to him (from a place not stated) by a messenger (identity not stated), who received no less a reward than the prodigious sum of 600 imperial ducats. Mr. Voynich has investigated very closely the hangers-on of Rudolf's establismment and the visitors thereto, and believes he has identified the man who brought him the cipher work.

John Dee was an English scholar, born in 1527, and died in 1608. Like so many of his contemporaries, Dee combined learning with politics, and was for many years in favor at the court of Elizabeth. In particular he acted, on more than one occasion, as her envoy or special messenger to Rudolf in Prag.

This of itself would be far from conclusive—presumably there were other Englishmen of the period who went to Prag once, or twice, or even more often. But the interesting feature of Dee's visits is that he was a tremendous Bacon enthusiast. He had a collection of Bacon manuscripts exceeding anything before or since—the largest accumulation of these ever got together. On the continent, where Bacon's name and fame had gone into eclipse because of the prevailing orthodox Catholicism of these countries, Dee is known to have definitely revived interest in his work to such an extent that one of Rudolf's scientific satellites was proud to bear the designation "The Lesser Bacon." In view of Dee's great preoccupation with Baconia and the known fact that he went as a confidential messenger to Rudolf on several occasions, Mr. Voynich's conclusion that he was the mysterious messenger who brought him the cipher manuscript seems sufficiently reasonable to stand up under fire.



THE PAGE ON WHICH THE STATEMENT OF THE ANNULAR ECLIPSE OCCURS
The central drawing is taken to be a representation of this eclipse; the significance of the others is not apparent.

Dee's known possession of a huge number of Bacon manuscripts is of course a great point in support of this contention. Just where he got these, and in particular the one in which we are interested, does not clearly appear. He was acquainted with the ducal house of Northumberland, and it was through this channel that he got the foundation for his collection, adding to it independently later. There seems no ground for hoping that his source for this one manuscript can ever be identified.

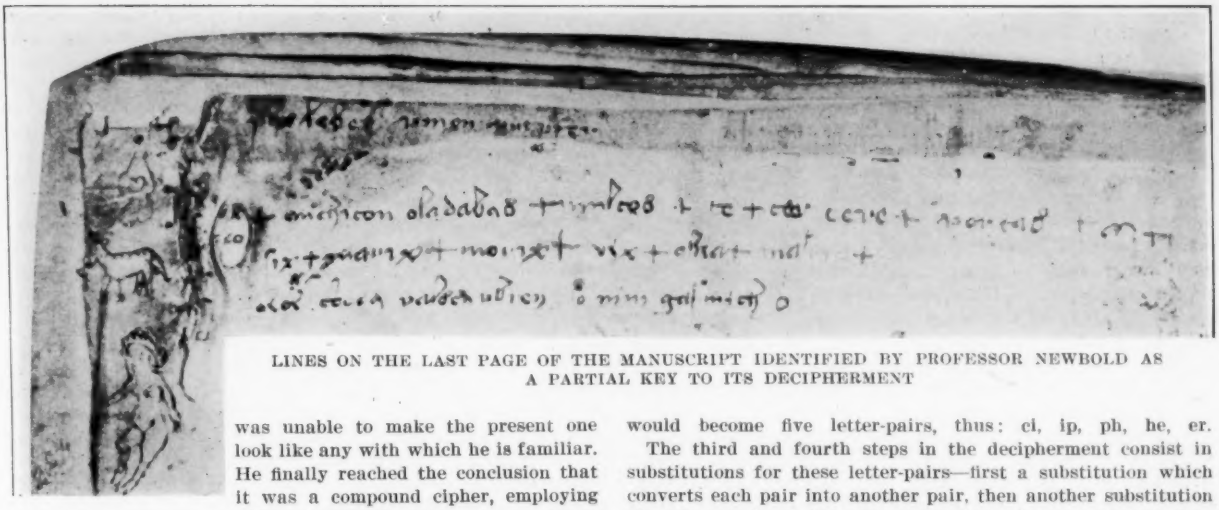
It appears therefore that an entirely reasonable chain of ownership can be exhibited running from a man who is known to have owned practically all the Bacon manuscripts that exist, to a man who is known to have owned this particular manuscript. No absolute proof to speak of is offered, but an entirely plausible history for the manuscript running from, say, 1550 to the present moment has been indicated. This is of particular bearing in that it accounts so satisfactorily for the transfer of the document, first from Oxford to Prag, and later to Parma. While not proof, it comes about as close to being proof as we can usually hope to come in the case of a medieval manuscript that has passed through private ownership.

With this side of the matter disposed of to our satisfaction we may turn to the problem of translation. Professor Newbold assures us that this is a task of extraordinary difficulty—so much so that he doubts that the manuscript will ever be read, in its entirety, with scientific accuracy. In any event it is a labor for many years and numerous hands. He believes he has succeeded in driving the entering wedge, to the extent of learning the general principles governing the cipher used; and that he has applied these principles in translating the text, with a degree of success that justifies their acceptance.

The last page of the manuscript, according to Professor Newbold, offers the key to the situation. It is unillustrated, while all the other pages are freely adorned with the drawings to which we have referred; and instead of being a full page, it consists of but two or three lines near the top of the sheet. It is entirely reasonable to suppose that it is not actually a part of the manuscript, but that it represents a memorandum of some sort. It is, however, by the scribe, and not by a later owner. It is therefore again reasonable to suppose that it has something to do with the cipher.

A careful inspection of this memorandum shows that it consists in part of the sentence, which looks somewhat like Latin and somewhat like nonsense, "michiton oladabas multos te fecr cerc portas." Supplying a preposition in place of the chewed-off corner of the manuscript, and dropping so much of this inscription as is on its face nonsensical, Professor Newbold finds that the rest shakes down to the sentence "A mihi dabas multos portas." In spite of the disagreement between multos and portas, he decided that it meant what it must mean if it means anything—"Thou hast given me many gates," and that in some way this was a key sentence to the cipher.

Professor Newbold has a wide acquaintance with ciphers, but



LINES ON THE LAST PAGE OF THE MANUSCRIPT IDENTIFIED BY PROFESSOR NEWBOLD AS A PARTIAL KEY TO ITS DECIPHERMENT

was unable to make the present one look like any with which he is familiar. He finally reached the conclusion that it was a compound cipher, employing different systems in such a manner that in decipherment he would have to unravel each step separately, no combination of the several steps into a single resultant step being possible. Later he concluded that the final step of the encipherment had been the reduction of the Roman letters of the message to a short-hand of some sort. He finally satisfied himself that he had identified this system, fifteen of the characters being taken from a known short-hand system of the ancient Greeks, and the other seven, which he succeeded in identifying, having apparently been of the scribe's own invention.

The nature of this short-hand is quite extraordinary. The several signs consist of minute marks, gradations and shadings which can be incorporated into the ordinary letters, a number of them in each letter at the same time, in fact. They have to be read with a glass of some sort. The variation of one-fiftieth part of an inch, says Professor Newbold, makes all the difference between one sign and another. Practicable on vellum, he believes the system could not be used on paper, with its fibers that would appear as marks on the surface and be confused with the marks of the cipher.

After the apparent letters of the text have been replaced, using the short-hand key, by the letters for which they stand, the text will have been expanded to considerably more than twelve times its original bulk—few of the letters consist of less than this number of individual characters, many of them contain more. A single word of seven letters in the text, which Professor Newbold used for demonstration purposes, he broke down into 172 Roman letters.

The second step consists in grouping the letters thus derived into pairs, supplying a duplicate of each letter so that the pairs interlock. An example will make the process clearer than any amount of explanation could hope to make it. The word "cipher," treated after this scheme, would become five letter-pairs, thus: ci, ip, ph, he, er.

The third and fourth steps in the decipherment consist in substitutions for these letter-pairs—first a substitution which converts each pair into another pair, then another substitution changing each of the new pairs back into a single letter. Professor Newbold has not in any of his public utterances explained satisfactorily how, in the original encipherment, it is possible to bring it about, as the result of the inverse substitutions, that we should get letter-pairs that interlock as in the above example. Certainly if we take an arbitrary series of single letters, say, "abcdefg," and substitute for each letter a pair of letters, then for each pair another pair, it does not seem as though we could, in general, anticipate that any such interlocking arrangement would hold. This would indicate that, if Professor Newbold really has hit upon a valid scheme for decipherment, he does not actually reverse the original steps of encipherment, but employs a process, presumably more complicated, which turns out to give the same result. In a single-step cipher this could hardly occur, but in a cipher of six stages, as this one is stated to be, we should think that a result of this character would be about as probable as direct solution by actual reversal of the enciphering processes.

PHOTOGRAPH OF THE GREAT SPIRAL NEBULA OF ANDROMEDA

Because of the inclination of its plane with respect to our line of vision its spiral form is not evident except as viewed through a powerful telescope

The fifth and sixth stages of the decipherment process are those which will stick hardest in the throat of layman and mathematician alike. The one consists in a substitution which follows no fixed rule but is more or less arbitrary; the other in a rearrangement, at pleasure, of the letters resulting from the fifth step, so that they shall make up words. Professor Newbold tries to reassure us here by telling us that he considers no passage successfully translated until he has effected such an anagrammatic readjustment which shall use up all the letters and make sense. Our only comment upon this is that we should hope he would concede this much to the critics, at the very least, without boasting about it. Indeed, in the absence of definite information as to just how large a section of the original Professor Newbold shakes up in his anagram machine at one operation, there is little more to

say. If only a score or so of letters, he of course can exhaust the possibilities and show that no other arrangement is possible. If he allows himself a greater latitude he cannot always do this. Again, if he employs a consistent and constant method of deciding just how much text to include in each of his shufflings, he is on better ground than if he takes as much as he needs to get letters which he can twist into sensible Latin.

It will be inferred from this account that the writer is not enthusiastic about Professor Newbold's translation. Professor Newbold himself admits the serious ambiguity of his process; he states explicitly that at two stages of the decipherment the indeterminate element enters so strongly that there is presented the necessity for exercising what he calls "judgment." We have another and slightly less impressive word for this—it is "guessing." Unless the guessing can be eliminated, we do not regard Professor Newbold's claims that he has translated the cipher as warranted.

As a matter of fact, Professor Newbold realizes this himself, we believe. For one thing, he emphasizes that the translated text and the picture ought to harmonize. This is true enough, but we are surprised that it is urged in favor of the "decipherment." For in practically every case where "decipherment" has yet been effected, the picture is such as to suggest quite strongly, not perhaps what the text should say in order to harmonize, but at least what it should talk about. Guessing with a guide, even one which is followed unconsciously and without evil intent, is not the same as just guessing; the result at once begins to depend upon the guide as well as upon the guesser.

In at least two cases Professor Newbold has scored what he puts forward as a notable triumph. One of the drawings was submitted to an astronomer for an opinion as to what it represented; the verdict was that it unquestionably was a crude effort to draw a spiral nebula. After much work on the caption of this drawing—that is to say, upon what a modern editor would call its caption—Professor Newbold evolved out of it a statement that, using a refracting mirror, the scribe had seen, at a point in the heavens which he identifies in terms of the Navel of Pegasus and other ancient marks, a star shaped like a snail shell. His localization of this apparition is a very good amateur attempt to describe the position of the Great Nebula of Andromeda. This page is the basis for the claim that Bacon discovered the telescope.

In another case we have a drawing, reproduced herewith, which we think will be agreed to have strong astronomical leanings. The translator found in connection with this the statement that the observer had seen what he described in terms showing clearly that he is talking about an annular eclipse; and the date of the observation is given. Checking up by the department of astronomy verified this date (in the thirteenth century, of course) as that of an annular eclipse. And when we have had it suggested to us, we can see that there are things which the drawing resembles less than it does an annular eclipse.

Professor Newbold states that in both cases he was quite without the knowledge in point until he had read it in the manuscript. Leaving quite aside the question of his good faith, we wonder whether he is sure of this. He has done a vast amount of reading in connection with medieval manuscripts and medieval lore in general. It is not for a moment to be supposed that he consciously remembers everything that he has ever thus read. In view of the mathematical probabilities inherent in the methods of decipherment which he permits himself, we consider it at least equally likely that something which he has read has cropped up subconsciously and influenced his translation, as that he has really reproduced the words of his original.

As a matter of fact, in the case of the Andromeda nebula, the translator is sufficiently out of luck to suggest strongly that this is what has happened. The ordinary spiral nebula does look much like a snail shell, and might very likely be thus described by one seeing it for the first time; and the Andromeda nebula is a spiral one. But it just happens that we are looking at this nebula almost due edgewise, so that the spiral effect is greatly masked by perspective; our photograph shows this clearly. We have the gravest doubt that anyone not thoroughly acquainted with spiral nebulæ and star clusters would ever identify this object as of the former rather than the latter class, or ever see a snail-shell effect in it. And when Professor Newbold's colleagues of the department of astronomy assure him that Bacon couldn't have seen this nebula as a spiral—even as so much of a spiral as our picture reveals it to be—without a telescope, they are putting it mildly; they might equally have said that he couldn't have recognized this feature of it without a telescope of decidedly high power.

We are rather inclined to accept the manuscript as from Bacon. Until further progress is made, and in the expectation that further progress, if it is made, will result in the further rationalizing of some of the steps of decipherment, we are not prepared to accept the translation. Professor McClung, when called upon to substantiate the claims of Professor Newbold that certain of the drawings possessed certain biological significance, came as close to flat contradiction of this possibility as the courtesies of the occasion permitted. He did flatly contradict it, so far as his own judgment was concerned, in seven out of nine exhibits; in the other two he was not so certain but it was plain that he felt the symbolism of the drawings to be so excessive that no objective representation could properly be claimed for them. Our state of mind with regard to the cipher rendition is about the same as his with regard to the drawings. The manuscript and the efforts to read it are of extraordinary interest; but we do not consider that definite statements of results should have been made at the present stage.

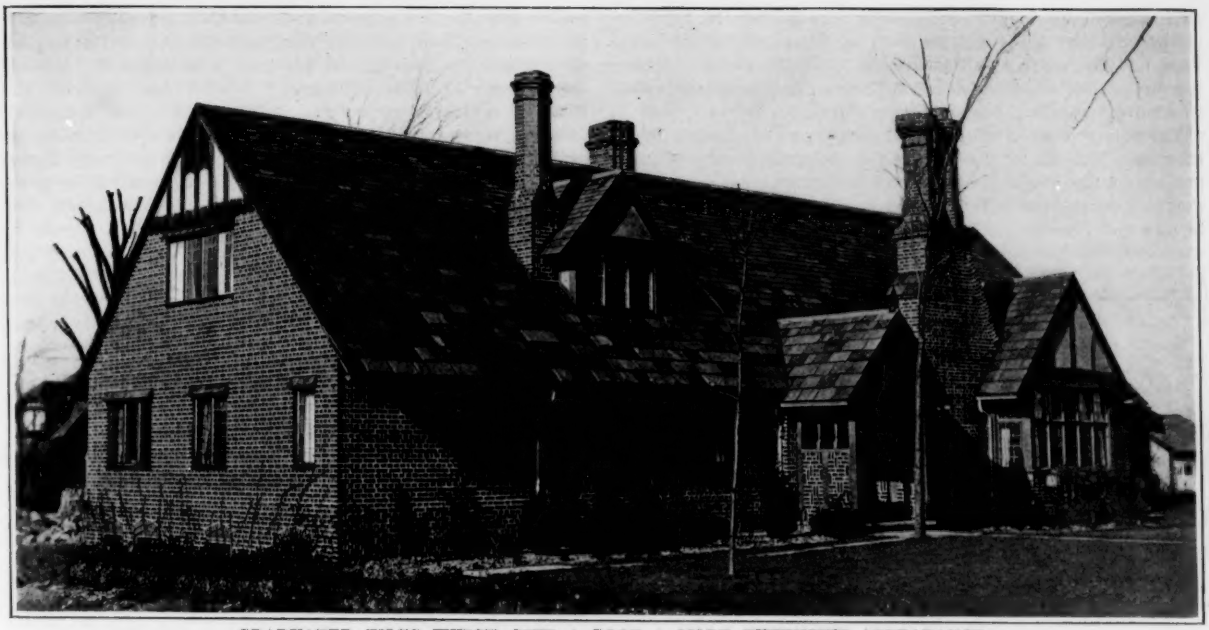
It will be remembered that the Shakespeare-(Francis) Bacon cipher possessed an indeterminate element, in that the reader might look in a large number of places for the next letter. The enthusiasm of those who claimed that Shakespeare didn't write the plays waned noticeably when some mathematically inclined gentleman—was it the astronomer, Proctor, in the remarkable paper, "Knowledge," which he edited for some years?—showed that with the freedom of judgment exercised, the probabilities were many millions to one that the desired message could be found. When Professor Newbold incorporates two indeterminate steps into his decipherment, he does not seem to be on any better ground than the lamented Ignatius Donnelly.

TREPHINING AMONG THE PREHISTORIC INDIANS

TREPHINING was of common occurrence among prehistoric Indians of South America, and is still practised in Bolivia and Peru. Where stones from slings, the "bola" or "lliui" and wooden clubs with heads of stone and copper were the common offensive weapons, complex fracture of the skull with depression of the bony plates must have been very common. A fracture of the skull sometimes resulted in almost instant death, but many victims survived wounds of this sort, and an attempt to remove splinters of bone that pricked the brain, or to cut out fragments that pressed upon it, must have become, at an early date, a natural procedure.

To the American Museum of Natural History belongs credit for investigations in Peru and Bolivia which revealed much interesting information as to ancient pathology and surgical practices in these regions. Of nearly 1,200 skulls collected on one Museum expedition in Bolivia, conducted by the late Dr. Adolph Bandelier, about 5 per cent of the skulls had been trephined. The members of the party discovered, furthermore, that trephining is practised in Bolivia today, by medicine men. The operation is performed with any available cutting instrument, and the process is one of incision and scraping.

The Indians apply "coca" to wounds, bruises and contusions for healing purposes, and it tends to deaden pain.



GRADUATED TILES WHICH GIVE A ROOF A MORE EXTENSIVE APPEARANCE

Visual Illusions in the Arts*

Tricks of Lighting, Color and Form for Painters, Sculptors and Architects

By M. Luckiesh

IN the arts where colors, brightnesses, contrasts, lines, forms, and perspectives mean so much, it is obvious that visual illusions are important. Sometimes they are evils which must be suppressed; in some cases they are boons to the artist if he is equal to the task of harnessing them. Oftimes they appear unheralded and unexpected. The existence of visual illusions is sufficient to justify the artist's pride in his "eye" and his dependence upon his visual judgment rather than upon what he knows to be true. However, true this may be, knowledge is useful to the artist as it is to any one else. The artist, if he is to produce art, is confronted with the tremendous task of perfecting an imperfect nature and he is handicapped with tools inferior to those which Nature has at her disposal. He must deal with reflected lights from earthly materials. Nature has these besides the great primary light-sources—the sun, the moon, the stars, and, we might say, the sky. She also has the advantage of overwhelming magnitudes.

A painting in the broadest sense is an illusion for it strives to present the three-dimensional world upon plane areas of two dimensions. Through representation or imitation it creates an illusion. If the artist's sensibility has been capable of adequate selection, his art will transmit by means of and through the truths of science, from the region of perception to the region of emotion. Science consists of knowing; art consists of doing. If the artist is familiar with the facts of light, color, lighting, and vision, he will possess knowledge that can aid him in overcoming the great obstacles which are ever-present.

The artist may suggest brilliant sunlight by means of deep shadow. The old painters gained color at the expense of light and therefore lowered the scale of color in their representations of nature. It is interesting to see how increasing knowledge, as centuries passed, directed painters as it did others onward toward the truth. Turner was one of the first to abandon the older methods in an attempt to raise the scale of his paintings toward a brilliance more resembling nature. By doing this he was able to put color in shadows as well as in lights. Gradually paintings became more brilliant. Monet, Claude, and others worked toward this goal until the brightnesses of paintings reached the limits of pigments. The impressionists in their desire to paint nature's light introduced something which was nothing more nor less than science. All this time the true creative artist was introducing science—in fact, illusions—to produce the perfect illusion which was his goal.

In the earliest art, in the efforts of children, in the wall-paintings of the Egyptians, and in Japanese representation of nature, the process is selective and not imitative. Certain things are chosen and everything else is discarded. In such art selection is carried to the extreme. Much of this simplicity was due to a lack of knowledge. Light and shade, or shading, was not introduced until science discovered and organized its facts. Quite in the same manner linear and aerial perspective made their appearances until in our present art the process of selection is complex. In our paintings of today objects are modeled by light and shade; they are related by perspective; backgrounds and surroundings are carefully considered; the proper emphasis of light, shade and color are given to certain details.

The painter can imitate aerial perspective although many centuries elapsed before mankind was keen enough to note its presence in nature. The atmospheric haze diminishes the brightness of very bright objects and increases that of dark objects. It blurs the distant details and adds a tinge of blue or violet to the distance. In painting it is a powerful illusion which the painter has learned to employ.

The painter can accurately imitate mathematical or linear perspective but the art of early centuries does not exhibit this feature. In a painting a tremendously powerful illusion of

*Excerpts from a forthcoming book by the author on "Visual Illusions."

the third dimension is obtained by diminishing the size of objects as they are represented in the distance. Converging lines and the other manifold details of perspective are aiding the artist in his efforts toward the production of the great illusion of painting.

The painter cannot imitate focal perspective or binocular perspective. He can try to imitate the definition in the central portion of the visual field and the increased blurring toward the periphery. Focal perspective is not of much importance in painting because it is scarcely perceptible at the distances

FIG. 1. EFFECTS OF GRAIN IN A PICTURE FRAME
The horizontal sides appear bowed up in the middle and the vertical sides bowed to the right

at which paintings are usually viewed. However the absence of binocular perspective in painting does decrease the effectiveness of the illusion very markedly. For this reason a painting is a more successful illusion when viewed with one eye than with two eyes. Of course, in one of nature's scenes the converse is true because when viewing it with both eyes all the forms of perspective coöperate to the final end—the true impression of three dimensions.

The painter may imitate the light and shade of solid forms and thereby apparently model them. In this respect a remarkable illusion of solid form or of depth may be obtained. For example, a painted column may be made to appear circular in cross-section or a circle when properly shaded will appear to be a sphere. Both of these, of course, are pure illusions. Some stage paintings are remarkable illusions of depth and their success depends chiefly upon linear perspective and shadows.

The inadequacy of the range of brightnesses or values obtainable by means of pigments is not fully realized by the artist. The sky in a landscape may be thousands of times brighter than a deep shadow or a hole in the ground. A cumulus cloud in the sky may be a hundred thousand times brighter than the deepest shadow. However, the artist must represent a landscape by means of a palette whose white is only about thirty times brighter than its black. If the sun is considered we may have in a landscape a range of brightness represented by millions.

This illustrates the pitiable weakness of pigments alone as representative media. Will not light *transmitted* through media some day be utilized to overcome this inherent handicap of reflecting media? The range of brightness in this case may be represented by a black (non-transmitting) portion to the brightness of the background (artificial or sky) as seen through an area of clear glass.

It is interesting to study the effect of greatly increasing the range of values or brightnesses in paintings by utilizing non-uniform distributions of light. Let us take a given landscape painting. If a light-source be so placed that it is close to the brighter areas (perhaps clouds and sky near the sun) it will illuminate this brighter portion several times more intensely than the more distant darker portions of the picture (foreground of trees, underbrush, deep shadows, etc.). The addition to the effectiveness of the illusion is quite perceptible. This effect of non-uniform lighting may be carried to the extreme for a painting by making a positive lantern-slide (rather contrasty) of the painting and projecting this slide upon the painting in accurate superposition. Now if the painting is illuminated solely by the "lantern-slide" the range of contrast or brightness will be enormously increased. The lightest portions of the picture will now be illuminated by light passing through the almost totally transparent portions, and the darkest parts by light greatly reduced by passing through the nearly opaque portions of the slide. The original range of contrast in the painting, perhaps twenty to one is now increased perhaps to more than a thousand to one.

Many tricks may be interjected into the foreground of a painting for their effect upon the background and vice versa. For example, a branch of a tree drooping in the foreground apparently close to the observer, if done well will give a remarkable depth to a painting. Modeling of form may be effected to some extent by a judicious use of the "retiring" and "advancing" colors. This is one way to obtain the illusion of depth.

After-images play many subtle parts in painting. For example, in a painting where a gray-blue sky meets the horizon of a blue-green body of water, the involuntary eye-movements may produce a pinkish line just above the horizon. This is the after-image of the blue-green water creeping upward by eye-movements. Many vivid illusions of this character may be deliberately obtained by the artist. Some of the peculiarly restless effects obtained in impressionistic painting (stippling of small areas with relatively pure hues) are due to contrasts and after-images.

There are many interesting effects obtainable by judicious experimentation. For example, if a gray medium be sprayed upon a landscape in such a manner that the material dries in a very rough or diffusing surface some remarkable effects of fog and haze may be produced. While experimenting in this manner a very finely etched clear glass was placed over a landscape and the combined effect of diffusely reflected light and of the slight blurring was remarkable. By separating the etched glass from the painting a slight distance a very good imitation "porcelain" was produced. The optical properties of varnishes vary and their effect varies considerably, depending upon the mode of application.

All the means for success which the painter possesses are also available to the decorator; however, the latter may utilize some of the illusions of line, form, irradiation, etc., which the architect encounters. The decorator's field may be considered to include almost all of the painter's and much of the architect's. The decorator should begin to realize more

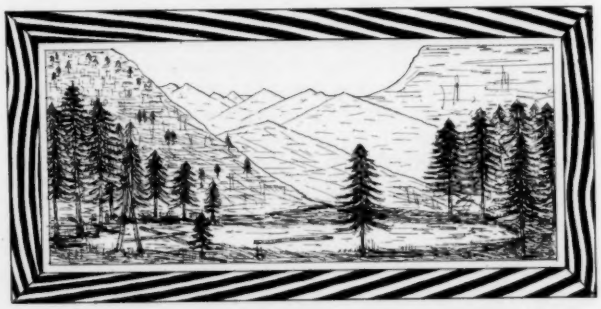


FIG. 2. THE GRAIN MAKES THE FRAME LOOK NARROWER AT THE LEFT THAN AT THE RIGHT

fully the great potentiality of lighting in creating moods or in giving expression to an interior. The psychology of light and the use of lighting as a mode of expression have barely been drawn upon by the decorator.

The practice of hanging pictures on walls which are brilliantly colored is open to criticism. The changes in the appearance of the object due to these highly colored environments are easily demonstrated by viewing a piece of white

paper pinned upon the wall. On a green wall the white paper appears pinkish; on a rose wall it appears bluish or greenish. A portrait or a picture in which there are areas of white or delicate tints is subject to considerable distortions in the appearance of its colors. Similarly, if a woman must have a colored background, it is well to choose one which will induce the more desirable tints in her appearance. The designer of gowns certainly must recognize these illusions of color which may be desirable or undesirable.

The quality of the light (its spectral character) may have an enormous influence upon the painting. In fact with the same painting many illusions may be produced by lighting. In general, paintings are painted in daylight and they are not the same in appearance under ordinary artificial light. For this reason the artist is usually entitled to the preservation of the illusion as he completed it. By using artifical daylight,

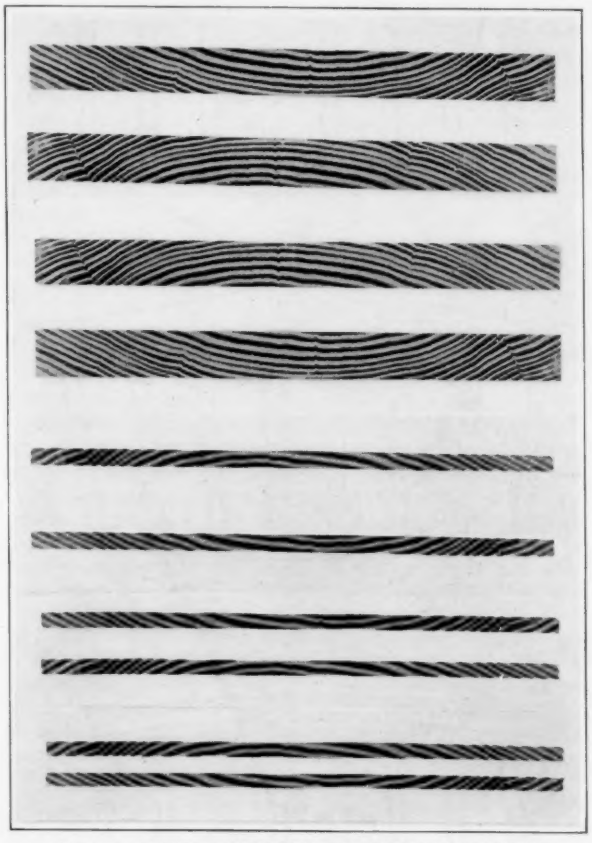


FIG. 3. VARIOUS DEGREES OF APPARENT WARPING DUE TO GRAIN

which has been available for some years, the painting appears as the artist gave it his last touch. Of course it is quite legitimate to vary the quality of light in case the owner desires to do so but the purpose here is to emphasize the fact that the quality of light is a powerful influence upon the appearance of the painting. The influence is not generally enough recognized and its magnitude is appreciated by relatively few persons.

All other considerations aside, a painting is best hung upon a colorless background and black velvet for this purpose yields remarkable results. Gray velvet is better, when the appearance of the room is taken into consideration, as it must be. However, the influence of dark surroundings toward enhancing the illusion is well worth recognizing. In the case of a special picture or a special occasion, a painting may be exhibited in a booth—a huge shadow-box not unlike a show-window in which the light-sources are concealed.

Incidentally on viewing some picture frames in which the grain of the wood was noticeable, the frames did not appear to be strictly rectangular. The illusions were so strong that only by measuring the frames could one be convinced that they were truly rectangular and possessed straight sides. Two of these are represented in Figs. 1 and 2. In the former the horizontal sides appear bent upward in the middle and the two vertical sides appear bowed toward the right. In Fig. 2 the frame appears considerably narrower at the left end than at the right. Both these frames were represented in the original drawings by true rectangles.

Many illusions are to be seen in furniture and in other woodwork in which the grain is conspicuous. This appears to the author to be an objection in general to this kind of finish. In Fig. 3 there is reproduced a photograph of the end of a board which was plane or straight notwithstanding its warped or bowed appearance. The original photographs were placed so as to be related as shown in the figure. Various degrees of the illusion are evident. The reader will perhaps find it necessary to convince himself of the straightness of the horizontal edges by applying a straight edge.

Many illusions are found in architecture and, strangely enough, many of these were recognized long before painting developed beyond its primitive stages. The architecture of classic Greece displays a highly developed knowledge of many geometrical illusions and the architects of those far-off centuries carefully worked out details for counteracting them. Drawings reveal many illusions to the architect but many

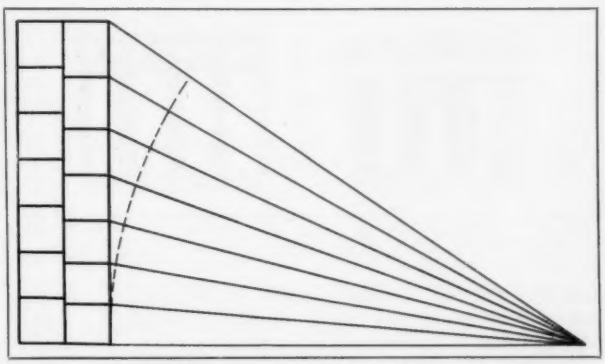


FIG. 4. DIAGRAM ILLUSTRATING WHY THE STORIES OF A BUILDING SHOULD INCREASE IN HEIGHT FROM THE GROUND UP IF THEY ARE TO APPEAR OF EQUAL SIZE

are not predicted by them. The ever-changing relations of lines and forms in architecture as we vary our viewpoint introduce many illusions which may appear and disappear. No view of a group of buildings or of the components of a single structure can be free from optical illusions. We never see in the reality the same relations of lines, forms, colors, and brightnesses as indicated by the drawings or blue-prints. Perhaps this is one of the best reasons for justifying the construction of expensive models of our more pretentious structures.

In architecture the eye cannot be wholly satisfied by such tools as the level, the square, and the plumb-line. The eye is satisfied only when the *appearance* is satisfactory. For the purpose of showing certain architectural illusions, the compensatory measures applied by the Greeks are excellent examples. These also reveal the remarkable application of science to architecture as compared with the scanty application in painting of the same period.

During the best period of Grecian art many refinements were applied in order to correct optical illusions. The Parthenon of Athens affords an excellent example of the magnitude of the corrections which the designer thought necessary in order to satisfy the eye. The long lines of the architrave—the beam which surmounts the columns or extends from column to column—would appear to sag if it were actually straight. This is also true of the stylobate, or substructure

of a colonnade, and of pediments and other features. These lines were often convex instead of being straight as the eye desires to see them.

In the Parthenon, the stylobate has an upward curvature of more than four inches on the sides of the edifice and of more than two and a half inches on the east and west fronts. Vertical features were made to incline inward in order to correct the common appearance of leaning outward at the top. In the Parthenon the axes of the columns are not vertical but they are inclined inward nearly three inches. They are said also to be inclined toward each other to such a degree that they would meet at an altitude of one mile above the ground. The eleven-foot frieze and architrave is inclined inward about one and one-half inches.

In Fig. 6 *a* represents the front of a temple as it should appear; *b* represents its appearance (exaggerated) if it were actually built like *a* without compensations for optical illusions; *c* represents it as built and showing the physical corrections (exaggerated) in order that it may appear to the eye as *a* does.

Tall columns if they are actually straight are likely to appear somewhat shrunken in the middle; therefore they are sometimes made slightly swollen in order to appear straight. This outward curvature of the profile is termed an entasis and in the Parthenon column, which is thirty-four feet in height, amounts to about three-fourths of an inch. In some early Grecian works it is said that this correction was over-

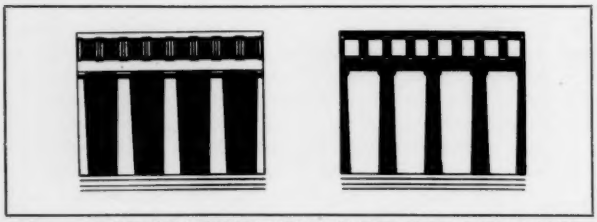


FIG. 5. COLUMNS VIEWED AGAINST THE SKY LOOK LARGER THAN WHEN VIEWED AGAINST A DARK BACKGROUND

done but that its omission entirely is quite unsatisfactory. Some authorities appear to believe that an excellent compromise is found in the Parthenon columns.

One of the conditions which is responsible for certain illusions and has been compensated for on occasions is represented in Fig. 5. On the left are a series of squares of equal size placed in a vertical row. If these are large so that they might represent stories in a building they will appear to decrease in size from the bottom upward, because of the decreasing projection at the eye. This is obvious if the eye is considered to be at the point where the inclined lines meet. In order to compensate for the variation in visual angle, there must be a series of rectangles increasing considerably in height toward the top. The correction is shown in the illustration. It has been stated that an inscription on an ancient temple was written in letters arranged vertically and in order to make them appear of equal size, they were actually increased in size toward the top according to the law represented in Fig. 4. Obviously a given correction would be correct only for one distance in a given plane.

The phenomenon of irradiation exerts its influence in the arts as elsewhere. For example, columns viewed against a background of white sky appear of smaller diameter than when they are viewed against a dark background. This is illustrated in Fig. 5 where the white and the black columns are supposed to be equal in diameter.

The careful observer will find numberless optical illusions and occasionally he will recognize an attempt on the part of the architect to apply an illusory effect to his advantage.

If a high wall ends in a series of long horizontal steps at a slightly inclined sidewalk, the steps are not likely to appear horizontal.

Some remarkable illusions of depth or of solid form are given to flat surfaces when snow is driven against it so as to adhere in decreasing amounts similar to shading.

A suggestion of augmented height may be given to a low tower by decreasing the size of its successive portions more rapidly than demanded by perspective alone. The same principle can be applied in many ways. For example, the roof in the photograph shown on page 498 looks very extensive particularly if viewed in such a position that the end-walls of the structure are not seen. Such illusions find applications in the moving-picture studio where extensive interiors, great fortresses, and even villages must be erected within small areas. Incidentally the camera aids to create the illusion

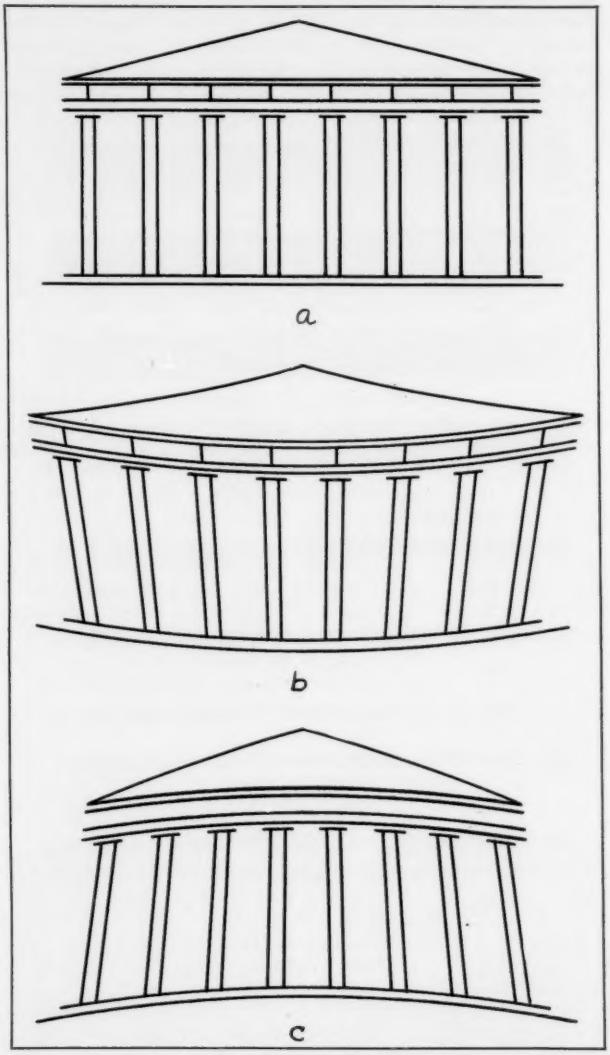


FIG. 6. ARCHITECTURAL ILLUSIONS

a, Front of temple as it should appear; *b*, appearance (exaggerated) if built like *a* without compensation for optical illusions; *c*, physical corrections (exaggerated) in order that it may appear as *a* does.

of magnitude in photographs because it usually magnifies perspective thereby causing scenes to appear more extensive in the photographs than in the reality.

Balance in architecture is subject to illusions and might be considered an illusion itself. For example, our judgment of balance is based somewhat upon mechanical laws. A composition must appear to be stable; that is, a large component such as a tower must not be situated too far from what we take as a center of gravity, to appear capable of tipping the remainder of the structure. In physics we would apply the term "moment." Each mass may be multiplied by its dis-

tance from the center of gravity, thus determining its moment. For a building or other composition to appear stable the sum of these moments must be zero; that is those tending to turn the figure in one direction must be counterbalanced by those tending to turn it in another direction. In appraising a composition, our intellect summates the effects of different parts somewhat in this manner and if satisfactory, balance is considered to have been attained. The colors of the various components exert an influence in this respect so it is seen that illusions may have much to do with the satisfactoriness of architectural compositions.

Various illusions of height of ceiling, composedness, etc., may be obtained by the color and brightness of the ceiling. A dark cornice in an interior may appear to be unsupported if the walls below are light in color, without any apparent vertical supports for the cornice. We are then subjected to the illusion of instability or incongruity. Dark beams of ceilings are not so obtrusive because our intellect tells us that they are supports passing over the top of the walls and are therefore able to support themselves. Color and brightness in such cases are very important.

The architectural details on exteriors evolved under daylighting outdoors so that their form has been determined by the shadows desired. The architect leads his lights and shadows around the building modeling it as he desires. An offset here and a depression there models the exterior in light and shade. The forms must be powerful enough to resist the obliterating effect of overcast skies but notwithstanding all precautions the expression of an exterior varies considerably with nature's lighting. Indoors the architect has a powerful controllable medium in artificial light which he may draw upon for producing various expressions or moods in rooms. The effect of shadows is interesting when viewing some structures flood-lighted at night. In those cases where the light is directed upward there is a reversal of shadows which is sometimes very unsatisfactory.

It is interesting to experiment with various ornamental objects lighted from various directions. For example, a Corinthian capital lighted from below may produce an unpleasant impression upon the observer. We do not like to have the dominant light from below perhaps because it is annoying to the eyes. Possibly this is an instinct acquired by experience in snow-fields or on the desert, or it may be a heritage of ancestral experience gained under these glaring conditions. This dislike manifests itself when we appraise shadow-effects and therefore our final impression is tempered by it.

All sculptured objects depend for their appearance upon the lighting, and they are greatly influenced by it. In sculpture, in a strict sense, illusions play a lesser part than in other arts. Perhaps in those of very large proportions various corrections have been applied. A minor detail of interest is the small cavity in the eye, corresponding to a reversed cornea. This depression catches a shadow which gives considerable expression to the eye.

Principles of Modern Psychology

Enabling the Individual to Develop His Good Points to the Best Advantage

IN *Mental Hygiene* for Jan., 1921, Dr. W. A. White presents an important analysis of the Principles of Modern Psychology with especial reference to "The Behavioristic Attitude." Behaviorism, says Dr. White, looks upon what a man does in contrast to what he thinks and feels—that is, upon his conduct—as being the most important expression of his psychology. In other words, his actions are taken as the only authoritative expression of what he is. Thinking and feeling have significance only so far as they are preparatory for and lead to action. The man who thinks and feels, but does not translate his ideas and emotions into action, is hamstrung by doubt. Failure to act in the ordinary sense is, however, itself action. A body comes to rest only because the forces that act upon it are for the time being in equilibrium.

The outstanding fact is that organisms are constructed on a pattern which has action for its purpose. Life itself has been defined as consisting of that constant back-and-forth flow of energy which constitutes the relation of the organism to its environment. Every change in the environment must be met by an adjustment on the part of the organism, and that adjustment involves action, or expressed in physiological terms, reaction. The adjustment effected brings the organism into functional contact with the environment at more points than before and therefore necessitates further reactions of adjustment, the growing number and complexity of which constitute development in the individual and evolution in the race. This fact alone justifies the emphasis of the behaviorists on conduct.

The great change that has come over psychology in recent days is, then, that it has been humanized. In the days when psychology was metaphysical and academic, it was a subject for meditation in one's study; it had, strangely, almost no touch with the living, pulsing problem of human life. It was more interested in discussions of the nature of the soul than in such questions as why men failed in life. Failure of any kind was hardly recognized as a biological problem of adjustment, and so its real psychological significance failed of appreciation. Now, however, the whole tendency has changed, and it is just such problems as the criminal, the insane, the defective, the vagabond, the prostitute, the neurotic, and all sorts of minor disabilities that interest it most.

To come to the question of the Why of some of these failures is to revert to the fundamental behavioristic conception of man as a complex of action systems or action patterns.

One of the very obvious reasons for faillure lies in the fact that the machinery which a man has at his command, *i.e.*, his bodily machinery, his vital organs in all their complexities and intricate interrelations, is inadequate to the carrying out of a socially acceptable life plan.

An astonishingly large percentage of the unfit, the social outcasts, are seriously handicapped by bodily disease, while approximately 50 per cent of all classes are as seriously impaired by obvious or comparatively easily discoverable mental disease.

The two classes are, however, not so widely separate as this statement would lead one to believe. We have passed out of that stage of evolution in which success was solely a matter of blood and brawn, strength to kill or fleetness to escape, and are living in a period in which the struggle for survival, for success, is a contest of wits, a matter of brains. Therefore, we may look upon failures of adaptation as predominantly failures at the psychological level.

The organism is something more than a collection of organs; it is a collection of organs that are related in such a way that they may all, like the several parts of a complicated machine, be brought into the service of a common purpose, and the head end is the device from which emanates the directing force for such integrated activities.

Body and mind are, then, not separate; they have grown up and evolved together as part and parcel of the same thing, the one consisting of the parts, the other of the integrated relation of the parts.

Behavior, then, is seen to be of necessity the final expression in action of the whole, so to have the importance that the behaviorists attach to it. Defects in the individual—whether they be of mental or of bodily origin, whether they depend upon mind in the first instance or are traceable and dependent upon some defect of an organ, such as blindness—ultimately find their expression in conduct.

Failures are not, despite the fact that they often appear to be, solely individual affairs, but defects at the level of ad-

justment between the individual and his fellows, or at the psycho-social level. It is because this is so that the large class of unfit are social problems.

Now society has always, heretofore, been primarily and, for that matter, solely interested in the conduct of its members, in their acts, and whenever it has found some one doing things that tended to its disadvantage, it has sought to put a stop to such acts with very little thought of the actor, the doer of the act. It is as if you should consult a physician for a pain in your leg and he should at once relieve you of the offending member by amputation.

With increased knowledge, there has come a realization that there are other ways to tackle the problem that are more rational and bid fair to attain better results. The tendency in dealing with the delinquent, defective and delinquent classes today is a tendency toward a greater individualization, a tendency to deal, in other words, with the actor rather than with the act.

At this point Dr. White parts company with the extreme behaviorists who would discredit the internal evidence entirely. For the behaviorist what a person thinks and feels is of no significance, and to society what a person thinks and feels matters not at all. It is only what one does that counts. But psychologically, from the standpoint of the organism as a complex of action systems, thinking and feeling are but acts *in statu nascendi*. Many acts never get beyond the thinking and feeling stage, are never translated into conduct, and in connection with every one that is, there are certain other, counter assertions, of opposing tendency, which, while they do not gain frank expression, are at least able to modify to some extent those that do.

This arrangement by which conduct is the result of choice between opposing tendencies, each of which with varying force tries to avail itself of the machinery of expression, is *the plan upon which the organism is built up*. This is a figurative way of putting the case for what the psychoanalyst calls the *wish*. All of these tendencies within the psyche which are struggling for expression are wishes in the sense of this school, and it is only by knowing what they are and their relative strength that a dynamic plot, so to speak, can be made of the personality.

The wish to conform, to be well thought of by one's fellows, is practically always dominant, but behind each such wish there is another, antisocial, infantile in tendency, that also seeks expression. The first is almost sure to succeed, but the degree of its success is measured by the strength of the second.

For example, the soldier who was afraid to go forward was also afraid not to because of the discredit his failure would bring in the opinion of his associates. For the same reason he was afraid to run away. The dread of loss of social esteem was often sufficient to over-balance a fear that was not strong enough to be controlling, and he went forward. But for some the fear of going forward was so great that it was impossible to do so. Equally, death faced them in the form of a firing squad if they ran. The solution was, say, a neurotic paralysis of the legs which so crippled them that they could not walk, much less go forward or run away. The solution of the *impasse* was illness, but the illness itself was a concession to the social demands. Illness is respectable, cowardice is not.

There are now two approaches in helping to better inadequate adjustments. One may try to change the individual, as already indicated, or one may try to change the circumstances. The former particularly requires a certain attitude of mind in oneself which is essential to success. It is the attitude of the scientist. It is impersonal in the sense, that it is not fraught with sentimentalism, which is dangerous, or with a sympathy that may be binding. It requires an understanding based on knowledge and an unqualified desire to bring to pass a better state of affairs, untinctured by self-seeking motives.

As showing the importance of this state of mind, it is known that the anti-social wishes that find expression in conduct are unconscious to their host. Modern psychology has demonstrated that the larger part of our mental life, that portion from which comes all the motive power for conduct, lies beneath the threshold of what we ordinarily call our conscious selves. This is the region in which all that complex battle of motives occurs which ultimately surges to the surface and finds expression in actions of which we are aware. Therefore, blame is an unscientific and useless attitude with which to approach an attempt to effect any change in the results.

Human nature has been in process of evolution a very long time. The period covered by history represents only a very short part of the time during which the process has been going forward. The differences between people are very much less than their resemblances, and those differences are in degrees of equipment, which make some a little better able than others to handle their problems. All have at their best something worth while, a percentage, be it ever so small, of efficiency, if only the circumstances are not made too hard. For these problems of society modern psychology is to find adjustment which will most nearly enable people develop their good points to the uttermost, which will help them to be of the maximum social value within their limitations.

This is the method of attempting to make available the energies of the individual to the best advantage. It is quite different from hanging a man because he has stolen two shillings, cutting off his leg because he has a pain in it, or discarding a broken part of a machine and putting nothing in its place. It deals with the human machine and with the social machine as with machines elsewhere—as means of utilizing energy.

THE DIET OF CAPTIVE APES

CAPTIVE apes have an unfortunate reputation of being filthy in their habits and, in particular, of spending much of their time in the Neapolitan practise of ridding themselves and each other of vermin. A well-known German naturalist, Dr. Th. Zell, thinks this reputation unjust and that the seeming search for vermin in the case of captive apes is really a search for crusts of salt, a habit to which they are driven by a lack of this element in their diet. Writing in a recent number of *Ueber Land und Meer* (Berlin), he says: "More than twenty years ago the old keeper, Huebner, in the Primate house at the Berlin Zoo, told me that his apes were quite free from vermin and that the public had an entirely wrong idea with respect to their supposed mutual search for parasitic insects. In his opinion the apes were really seeking dried cakes of sweat because of their salty taste. . . . In the newest edition of Brehm's Natural History, Professor Heck, the Director of the Zoo, expresses the same opinion. . . .

"In support of his view, Professor Heck remarks that captive apes seldom suffer from vermin. Wild apes, however, are certainly afflicted with parasites, with which African travelers often assure us they fairly swarm. Alfred Brehm, who lived in Africa for a long time, tells us that the leader of a troop of apes, who is always the strongest individual among them, is carefully deloused by the females under his command, and that this is one of their ways of pleasing and catering to him . . . and that he receives these courtesies with all the dignity of a Pasha served by his favorite slave."

With regard to tame animals the dirty and disgusting habits with respect to their food displayed in some instances, is held by Dr. Zell to be merely the attempt of an improperly nourished animal to supply some serious lack in its diet, and in behalf of this view he cites the following instances:

"Swine are semi-beasts of prey for whom a certain amount of flesh in their food is a necessity. In spite of this fact we confine our domestic swine to a vegetable diet alone and then express great wonder that a sow should be guilty of devouring her own litter. We are accustomed to provide our cows, goats and sheep with lumps of rock salt which they may lick at pleasure to satisfy the need of this mineral. . . . Our captive apes should have similar provision in their cages."

Chemical War on Disease*

Action of Certain Chemicals on Toxins That Are Responsible for Infectious Diseases

By Dr. H. Schwarz

DURING the past quarter century the medical sciences have made astonishing progress in all branches, but particularly in the field of serotherapy. This science constitutes, in actuality, one of the most powerful weapons available in the battle against a great number of infectious diseases.

SEROTHERAPY AND CHEMICAL MEDICAMENTS

However, many diseases are caused by protozoic infections, and such are very difficult to combat by means of serums. Sometimes this sort of treatment is altogether inapplicable and in these cases chemical methods of attacking the malady have proved to be very successful.

This marked the birth of a new branch of medical science, which has for its object the study of the action of certain chemicals on the toxins that are responsible for infectious diseases. It is also concerned with the destruction of the germs of disease by the aid of chemical substances within the body of the animal (the human body). Chemico-therapy is the name given to this new science, whose aim may be epitomized as "internal disinfection" of the human organism. Its task is to find chemical substances which are able to combine with the pathogenic parasites in the blood in such a manner that the latter are destroyed or rendered at least incapable of being propagated any further without these chemicals injuring in any way the organism itself.

PARASITOLOGY

Those substances which act on parasites are known as "parasito-tropes." Parasito-tropy takes place each time that the parasites are destroyed or isolated by the chemical molecules. However, the substances that are "parasito-tropic" in their action are also "organotropic," that is, they possess a chemical affinity not only for the parasites, but equally as well for certain vital organs or cellular tissues in the human body.

Hence, from the medical standpoint it is very essential to know both the organotropic and the parasito-tropic properties of a substance before it can be administered internally. The two must bear a definite relation to each other in obedience to a special parasitological law. The parasito-tropic properties must be stronger than the organotropic so that while the chemical destroys or neutralizes the germ it does not hurt the organism itself too severely.

THE THERAPEUTIC COEFFICIENT

It has been possible to foretell the action of a chemical medicament by determining its therapeutic coefficient. This is a mathematical quotient obtained by dividing the "curative dose" (C) by the "tolerated dose" (T).

The first thing to be done is to determine how much of the substance the organism can stand. Then it is found by tests just what quantity of the chemical will kill the parasite. From a chemico-therapeutic point of view it is evident that the most useful medicament will be the one whose "tolerated dose" is large in proportion to the "curative dose." In other words, the therapeutic coefficient should be as small as possible.

THE SALVARSAN COEFFICIENT

A very good example in the use of this coefficient is found in the arsenical medicament, salvarsan (the world-famous anti-syphilitic drug). The ratio $\frac{C}{T}$ varies according to the number of times a dose of the medicine is given. For the first time it is 300:800 or $\frac{1}{2.7}$ but as the human organism becomes accustomed to the action of the drug, the ratio diminishes, becoming 300:1000 or $\frac{1}{3.3}$ for the second dose and 300:1500 or $\frac{1}{5.0}$ for the third dose.[1] This explains why the first dose of salvarsan is always considered to be the most dangerous in its action on the system and why it is best to administer only a small amount of the drug at the outset.

ACTION "IN VITRO" AND "IN VIVO"

It has been observed that a great many substances are capable of destroying parasites when the experiment is made in the laboratory, in the test tube (in vitro), but are absolutely devoid of action on them in the human or animal body (in vivo). The parasito-tropic properties of the substance are then evidently much weaker than the organotropic properties. When the drug is administered internally it acts on the tissues and the organs far more than on the parasite. On the contrary, there are certain medicaments which are entirely inefficient in vitro but which give very excellent results in vivo.

Hence, there is no direct concordance between the reaction that takes place in the experimental apparatus and that in the body of the animal. Furthermore, neither is there any agreement between what happens in the animal body and in the human organism. Ehrlich has demonstrated that even when a substance has been tested out as carefully as possible and all the conditions have been chosen properly so as to yield the most accurate results, nevertheless it is not always possible to apply these results with safety in experimentation in the human body.

The importance of the conceptions of organotropy and parasito-tropy is paramount in the study of *immunity*. The experimental proof of the existence of chemical affinity between the parasitic cells and certain chemical substances, and other facts of like nature, derived from the results of actual experimentation have formed the basis of the "theory of lateral bonds."

THE THEORY OF LATERAL BOND

This theory has been the subject of numerous attacks, but it has proven to be of great service in explaining many facts which would otherwise be very difficult to understand. The fundamental principle, on which the theory is based, is that the living cell differs from lifeless matter in that it is able to choose from all the substances which may be found within the sphere of its action, those which are suitable to it and which can be useful to it. It is indifferent to all others.

THE CHEMICAL CONCEPTION OF THE THEORY

We are confronted here with the fundamental property of protoplasm, which we cannot explain. The best that we can do is to express what happens in chemical terms, which helps us to follow through the course of the phenomena, related thereto, more easily. We say that there must exist a "chemical affinity" between certain chemical groups in the living cell and certain chemical groups in the substance that is absorbed. Based on this assumption, it follows that each time that a cell absorbs or rejects a nutritive substance, the phenomenon of attraction or repulsion takes place between the various chemical groups. Hence, the cell changes its outward appearance in-

*Translated for the *Scientific American Monthly* from *Chemie et Industrie*, Jan., 1921, pp. 18-26.

[1]For "trixidine" (Sb_2O_3), the coefficient is 1:100—a very effective drug.

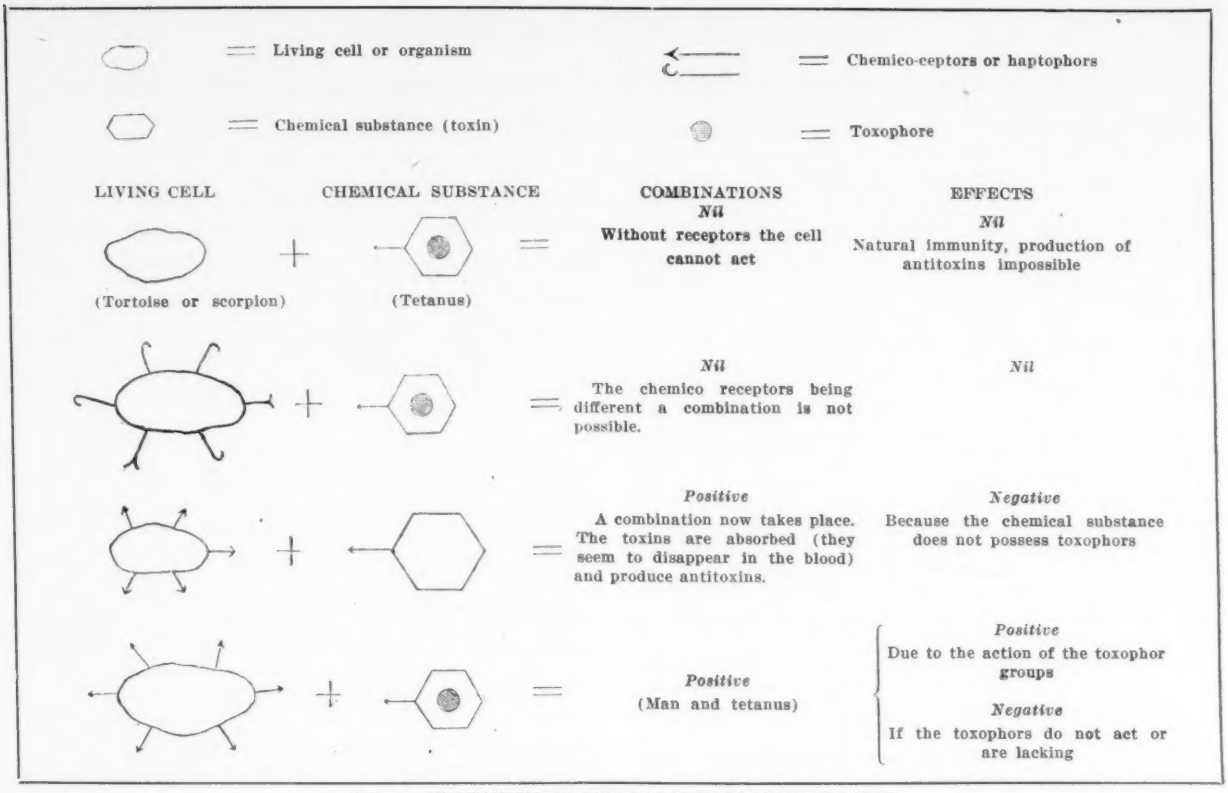


FIG. 1. MECHANISM OF THE PARASITOLOGICAL PROCESS

cessantly, which can be observed in the variation in the atomic concatenations. But in spite of the numerous modifications that take place in the cell no profound transformation occurs. It remains essentially the same until it dies.

THE STRUCTURE AND THE PLAY OF FORCES IN THE LIVING CELL

It is supposed that the cell contains in its center a vital nucleus, immutable in its substance, and responsible for the maintenance of the individuality of the cell. The central nucleus is conceived as being surrounded externally by many atomic bonds, which are very mobile, variable, and ever ready to detach themselves and to reëstablish themselves once more in combination with the nucleus. These bonds are the servants of the nucleus. Hence, everything that comes within the influence of the sphere of action of the cell, must first come in contact with these lateral bonds, or "receptors" as they were called by Ehrlich.

If it is assumed that every time that any substance whatsoever combines with the living cell, the association takes place because of a chemical combination, "effected by the lateral bonds," it follows that the living cell will give admittance to those substances only, which possess an affinity with its lateral bonds. This means that these bodies contain themselves groups, which are able to form chemical combinations with the lateral bonds of the cell. Whenever a substance is placed in juxtaposition to the cell, or whenever it penetrates it, then we attribute that phenomenon to the existence of atomic groups that combine with each other, and of which some belong to the lateral bonds of the cell and others to the substance in question. Ehrlich gave the name of "chemico-receptors" to the chemical groups, contained in the lateral bonds of the cell, and "haptophors" to the chemical groups in the chemical substance.

In order to avoid an erroneous interpretation of this theory it is to be remembered that it is not concerned with the absorption of nutritive solutions, such as sugar in solution, nor with toxic substances, such as arsenic, etc., for these substances are absorbed, as is known, not in accordance with the laws of diffusion, solubility, etc. The doctrine in question is concerned only with particularly complicated substances, which are not very soluble in water, as for example, albumen, the toxins, the ferments, etc.

A distinction may be made between two cases. In the first case a chemical substance is absorbed by the cell, provided the substance possess "haptophores" which are able to combine with the "receptors" of the living cell. In the other case, the substance is not absorbed. However, it is not enough to state that the substance is absorbed by the cell; it is necessary to explain in addition the *action of the substance on the cell.*

It is assumed that the substances, provided with "haptophores," contain characteristic atomic groups, which exercise a decisive influence on the nature of the reaction. This explanation is borrowed from the theory of dyestuffs. Just as there are certain groups which cause the dyestuff to fix itself on the fabrics and others which are responsible for the tone of the color itself, so in this case the influence of the active groups is not felt until the combination with the living cell has been accomplished. When the question is concerned with a toxic group ("toxophor"), then the cell is either destroyed or isolated. If there is no affinity between the "receptors and the haptophors," then the toxins have no action on the cell. (See Fig. 1.)

The mechanism of the parasitological process as depicted in Fig. 1 enables one to distinguish between the different degrees of sensitivity exhibited by animals toward various kinds of toxic substances. When an organism (as for example the tortoise or the scorpion) does not possess the necessary "receptors" to react with certain toxins (for example the tetanus toxin), then the latter has no effect on it. (This is shown in line 4 in the figure.) And likewise, neither do the cells of this organism attack the toxin. Hence, the toxin is absolutely neutral in the physiological sense. This explains why the tortoise or the scorpion is not affected by the tetanus virus and why this can circulate in the blood of the animal for many

days without being changed in any way. On the contrary, when the virus is injected into the human organism or in other animals that are sensitive to it, it begins to disappear at once, indicating that the cells of the body are attacking and destroying it. When as in the human body the "receptors" are numerous and localized in vital organs, the poisoning effect of the virus is intensified to a very marked degree.

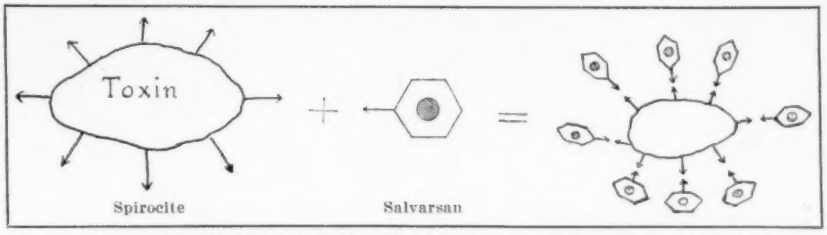


FIG. 2. DEATH OF THE CELL (SPIROCITE) BY COMPLETE POISONING
Combined effect of the toxophors and the liaison

NATURAL IMMUNITY

The definition of natural immunity is very readily developed from these facts. The blood cells of the tortoise or the scorpion not having the proper "receptors" do not combine with the tetanus toxin; hence, they are from their very nature immune to the disease. Of course immunity may be only partial. A regular scale of immunity to tetanus has been prepared. The horse is least immune, then come the mouse, the rabbit, the pigeon, the chicken and finally, the cold-blooded animals, the alligator and the tortoise, which are absolutely immune.

THE POSITION OF THE "RECEPTORS"

It has been developed that not only the number, but also the position of the "receptors" are determinant in establishing the immunity of an organism to certain parasites. The cells of the central nervous system are the only ones sensitive to the action of tetanus virus. Such cells are capable of transmitting the action of the virus and when this takes place in such a manner that the organ, menaced by the virus, is not entirely in danger, then the virus can be isolated without its action's entailing the death of the organism. The animal then also possesses "natural immunity."

THE PRODUCTION OF ANTITOXINS

A cell whose "receptors" are occupied by disease viri lives in a troubled state of existence. The "lateral bonds" of the cell possess a certain physiological function and that is suspended, due to the invasion of the cell by the pathogenic parasites. What does the cell do? It follows the natural physiological law in attempting to remedy the situation. All that it has the power to do is to replace the lateral bonds, occupied by the disease virus, by a new growth of the same.

It is a principle in physiology that, when a cell acts to compensate itself for the loss of something that it lacks, the compensatory process does not stop at mere replacement, but proceeds to the state of hyper - compensation. The cell secretes "lateral bonds" continuously, which are endowed with the same structural characteristics as those which have been destroyed. This process goes on until the cell cannot carry the large number of "lateral bonds" itself and must cast them loose. Then these "receptors" set free, circulate through the blood stream.

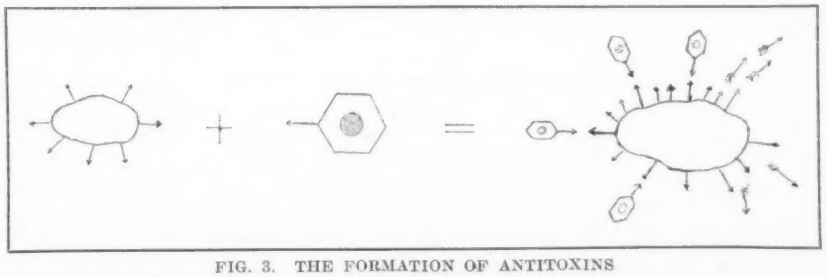


FIG. 3. THE FORMATION OF ANTITOXINS
A result of insufficient poisoning action and a consequence of the biological hyper-compensation

These organic particles contain albuminous substances characteristic to the organism in which they exist and hence are not subject to attack by the destructive forces of this organism. They remain intact for a long time. But, they possess a strong affinity for the virus which had occupied the cell by which they were produced. Hence, whenever they come in contact with the toxin a chemical reaction takes place and the toxin is destroyed just as happens in the case of the living cell. By virtue of their action on the toxins they are said to behave like "antitoxins." (The process of the production of these anti-bodies is shown graphically in the diagram Fig. 3, the detached "receptors" being represented by arrows.

THE ANTI-TOXINS

Hence, the anti-toxins are nothing more than the "chemico-receptors" which have become separated from a cell because of a physiological deficiency therein which gives rise to the phenomenon of hyper-compensation. It is impossible for a cell to produce anti-bodies when deprived of "receptors."

An analogy between the action of the anti-toxins and that of a lightning conductor is very striking. While the anti-toxin, that is the chemico-receptor which is endowed with a strong affinity for the "haptophore" of the disease virus is within the cell itself then it attracts the toxin to the cell. On the other hand, when it is without the cell, then it protects the latter because of its strong affinity for the toxin, whereby it forms with it an inactive combination and prevents it from exercising its death-dealing properties. The lightning rod attracts the lightning to the structure but by affording an easier path of escape protects it from destruction. A graphical demonstration of the process is indicated in Fig. 4.

THE ACTION OF ANTI-TOXINS

A useful application of the theory of lateral bonds is in the explanation of the effect produced by tetanus virus on the hen. To kill the fowl large amounts of the venom must be injected subcutaneously, but a comparatively small quantity will result in death when injected into the cranial cavity. It is evident that the cells in the nervous system are very sensitive to the poison. But there are also many cells in the subcutaneous tissue which are able to combine with the virus and to such an extent that the poison does not reach the central nervous system. That is why the fatal cranial dose does not kill the fowl when injected under the skin, but results in the formation of anti-toxins.

SENSITIVITY TO DISEASE AND PRODUCTION OF ANTI-TOXINS

It is not necessary that an animal be sensitive to a disease for it to produce anti-toxins which act against the disease virus. The reason for this lies in the fact that cells furnished with receptors may combine with the haptophors of the venom and produce anti-bodies but may not suffer any toxological effects therefrom. There is a very marked difference

between the function of the cell resulting in a "state of combination" and the "effect produced" in it.

Hence, the alligator which is absolutely unaffected by tetanus nevertheless produces large quantities of tetanus anti-toxin (*Compare diphtheria and the horse.* Trans.) On the other hand, the scorpion which is equally resistant to tetanus does not produce a trace of anti-toxin.

FIG. 4. NEUTRALIZATION OF THE TOXIN

The toxin is not poisoned by the antitoxin, as by chemical substances. It is only rendered impotent by the simple act of neutralizing or occupying its receptors

THE EFFECT OF TEMPERATURE ON IMMUNITY

Besides immunity due to the absence of the necessary groups in the cells of the organism to effect a combination with the disease venom, there is the immunity due to temperature which is of lesser importance. The only known case is that of the frog in its sensitivity to tetanus. The frog does not react to an injection of tetanus virus unless the temperature reaches 25 deg. cent. Then it dies. The explanation of this is that the toxophor group does not act without the aid of heat, although the toxin is already fixed in the cold.

While certain animals possess "natural immunity," that is, are insensitive to certain diseases from their very nature, others—in which category man is included—must have created in them an "antitoxinal immunity," that is, the capability to resist the disease by the formation of anti-toxins. Parasites (such as the tetanus bacillus, the diphtheria bacillus, etc.) are dangerous only when they have real toxic bodies in their organism. As soon as they have been deprived of these formidable weapons they become inoffensive parasites incapable of being propagated and which soon die. It is well known that very often there exists in the human body the parasites of disease—as for example the presence of the diphtheria germ in the throat—which, however, cannot cause any illness.

CHEMICO-THERAPY

As has been explained, chemico-therapy is the science which is concerned with treatment of disease by means of chemicals. The development of chemical medicaments which, when introduced into the system, will destroy the parasite without injuring the tissues of the bodies is based on the principles developed in the synthesis of dyestuffs. The question there is to produce certain changes in the color by the introduction of various groups in the compound. In chemico-therapy we are concerned with the variation in the physiological effect of a substance by the change in its composition through the substitution of one group for another. Ehrlich used his experience with coloring matters in his biological researches. He made tests on animals with more than two hundred dyestuffs. After they were injected into the blood of the animal he studied very minutely their distribution throughout the organism. Some substances appeared principally in the nervous system, others were fixed by the fatty tissues, etc. The *tropy* of a substance was thus determined as its aptitude to fix itself in a particular part of the organism. Substances which act on the brain are called neuro-tropic; those which act on parasites parasito-tropic.

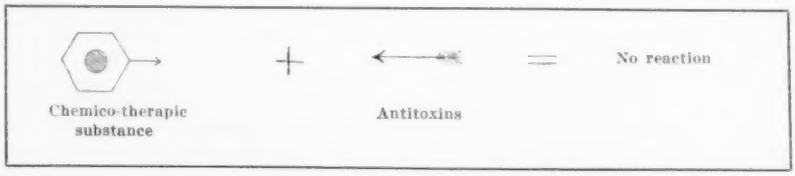


FIG. 5. NO REACTION

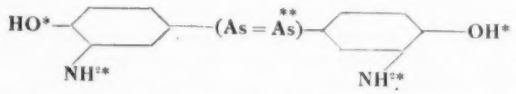
The antitoxins prefer the receptors of the cell to the haptophors of the chemical products

It was known for a long time that arsenic had a very strong action on the parasite which causes the dread disease syphilis. The chemical and physiological properties of the organic compounds containing arsenic were not understood very well. It was thought at first that the compound, atoxyl, would give very good results. This substance was considered to be a meta-arsenic anilide, possessing the formula $C_6H_5NH.AsO_2$. However, when it was injected into the human system, it produced blindness, although it killed the disease germ. The next step was to obtain another compound belonging to the same class as atoxyl, but not possessing its violent organo-tropic properties. Granting the above constitution to the compound, there was no hope of being able to modify the structure of it in order to obtain the desired amelioration of its toxic properties.

However, when this substance was examined more carefully, it was found that the original structure, assigned to it, was not correct. A compound was developed which was called theatoxyl of a sodium salt of para-amino-phenyl-arsenic acid. The formula of this substance is $p - C_6H_4NH_2.AsO(OH).ONa$. Here we have a substance which admits of many substitutions and additions. In the first place it is possible to change the amino (NH_2) group so as to get a series of many derivatives of the arsenic acid. Then again, the compound can be diazotized and numerous azo coloring matters synthesized therefrom. Other transformations can be made likewise, and in these ways a large number of compounds can be obtained, whose toxic properties can be regulated at will.

Starting with the original substance, atoxyl, and working various changes therein, Ehrlich finally succeeded in finding a compound which possessed the proper therapeutic coefficient and which gave good results in the treatment of syphilis.

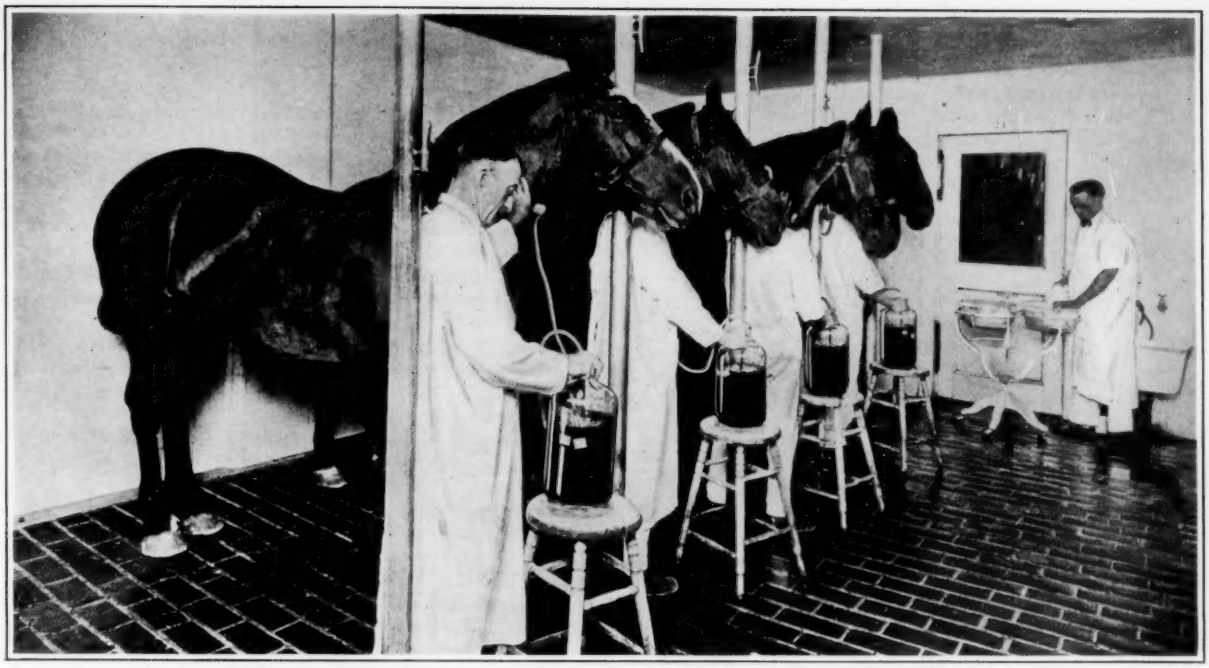
The study of the action of the arsenical compound on the syphilitic parasite, known as the spirochetic cell, revealed the fact that the cell possessed a number of different receptors. Among the most important of these were the oxamide and halogen receptors. The action of salvarsan on the parasite is now clear. Salvarsan is di-oxy-amide-arseno-benzene:



The haptophor groups OH and NH_2 combine with the receptors of the spirochetic cell and thereby prevent the cell from combining with the vital cellular substances of the human body. The toxophor group — As:As — destroys the cell. The presence of the NH_2 group close to the OH group enhances the fixative action of the OH group.

The importance of this comparatively new science of chemico-therapy is vital. The chemist now knows what is required from the chemical compound that he is developing for medical use. The future of the science is very promising.

*represents the haptophor group
**represents the toxophor group



BLEEDING HORSES FOR ANTI-PNEUMONIA AND ANTI-MENINGITIS SERUM
The operation is painless and the animals suffer no discomfort nor permanent injury

Vaccines and Serums

Modern Methods of Preparing Medicaments for Killing Microbes

By Donovan McClure

THE ancients had a saying, "Take a hair of the dog to cure its bite," a rough and ready sort of popular proverb to indicate the vague idea that in some cases like cures like or as the Latins had it *"Similia similibus curantur."* But it was not until Jenner discovered that the dread scourge of smallpox might be mitigated by inoculation with the virus of cow pox, a similar disease in a bovine host, that the idea began to really emerge from the shades of supersition which marked its early application.

The next great step was Pasteur's discovery that disease may be caused by bacteria or microbes. Later, Metchnikoff, the great Russian physiologist, discovered that those large white blood corpuscles which move hither and thither among their smaller cousins, the red blood corpuscles, in the plasma of the blood, have the remarkable property of being able to destroy such disease breeding bacteria as may make their way into the swift red current of life. Because of this power of absorbing and digesting pathogenic micro-organisms the leucocytes or white blood corpuscles are also known as phagocytes, *i.e.*, devouring cells. Some months ago the writer had the unusual privilege of being a guest at a demonstration of this subject given at the Rockefeller Institute in this city before an audience of physicians and nurses showing how this is accomplished. The lecturer was a brilliant young French surgeon attached to the Institute at that time and his lecture was accompanied by some very remarkable moving pictures showing one of these big soldier cells in hot pursuit of an invader. The audience was thrilled with excitement as the avenger swiftly and surely drew in upon the offending microbe, surrounded and demolished him and the volatile French physician shouted gaily "Atta boy, atta boy!" as the policeman drew near the criminal.

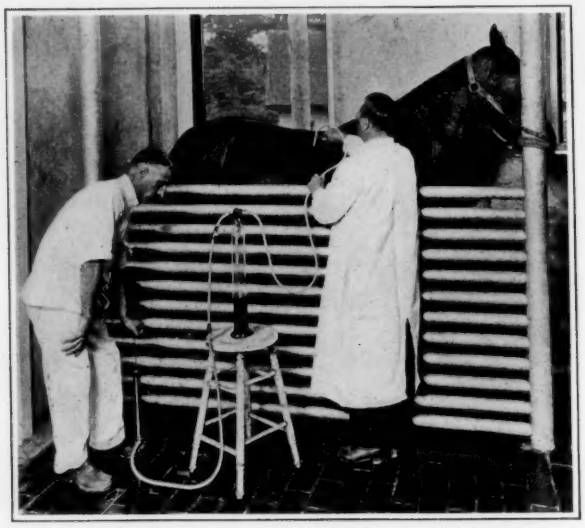
The next important step in advance was made by Sir Almoth E. Wright, the famous London physician, who did such good service in the war. In studying this phenomenon he found that this germ killing power of leucocytes is much greater when they are suspended in a blood serum obtained from animals which have been previously immunized than when they are floating in normal blood serum. He also found that the phagocytic power of the white blood corpuscles largely depends upon the presence in the blood serum of certain substances which act upon the invading bacteria in such a manner as to make them more readily susceptible to attack; in other words these substances, which were termed *opsonins* by Dr. Wright, are said to sensitize the enemy organism. Further study of the matter led Dr. Wright to conclude that during the process by which a living body obtains immunity from a given disease, these opsonins are greatly increased by the operation of natural forces, and he next discovered that they may be artificially increased by the injection of bacterial vaccines.

BACTERIAL VACCINES

Bacterial vaccines consist of dead disease germs suspended in what is known as a physiological salt solution, *i.e.*, a very weak solution of sodium chloride in water. This fluid is sterilized and is very carefully standardized by counting the number of bacteria, so that each cubic centimeter shall contain a definite number of them.

Therapeutic Action.—The power of bacterial vaccines to cure a disease or ameliorate its progress is due to the fact that they exert a stimulating action upon the cells of the patient's own body, causing them to increase their natural efforts of producing so-called anti-bodies. The word anti-body is analogous, roughly speaking, to the more familiar term of antidote, and the anti-bodies include not only opsonins, but agglutinins, precipitins, bacterial lysins, and other substances antagonistic

to bacteria. This heightened production of such protective substances leads to a state known as *active immunity*, and this well guarded condition often lasts for many years. The best known instance of such protection is smallpox vaccination.



METHOD OF INJECTING HORSES FOR THE PRODUCTION OF DIPHTHERIA AND TETANUS ANTITOXINS

The animal receives an injection every five days for from three to six months before there is any yield of antitoxin

Preparation.—Bacterial vaccines are prepared from cultures of pathogenic bacteria which have been grown upon suitable media under the most favorable conditions. *Several strains of the respective organisms are used* in the best laboratories for it has been demonstrated clinically as well as in the laboratory that different cultures of the same organism may vary widely in biochemic properties, and that most vaccines should be polyvalent in order to possess the greatest efficiency. *Polyvalent* means that the suspension contains several cultures of the same species of bacteria—that is, *several "strains" of the organism are used*—the cultures being obtained from many different sources of infection in which that species of organism is found. *All of the bacterial vaccines prepared in some antitoxin laboratories are polyvalent*—the single as well as the combined (mixed) vaccines. This statement, however, is not applicable to typhoid vaccine in which only one strain of the typhoid bacillus is used; because this particular strain has proved to be most efficient in the use of typhoid vaccine in the United States Army and in the armies of other countries. *A combined (mixed) vaccine* contains the various species of bacteria generally present in a mixed infection; for example, pneumococcus combined vaccine (mixed) contains the pneumococcus, streptococcus, and staphylococcus.

The bacterial cultures, which are usually grown on some solid medium, are washed off with physiological salt solution and thoroughly shaken to separate the organisms; the bacterial suspension is subjected to a careful count; the organisms are killed by heating the suspension and by the addition, after cooling, of 0.25 per cent trikresol. The suspension is then diluted with sterile physiological salt solution, containing 0.25 per cent trikresol, until each cubic centimeter contains the desired number of bacteria.

Uses.—Bacterial vaccines are used in acute, subacute, and chronic infections.

Since a large majority of diseases are due to mixed infections the combined (mixed) bacterial vaccines have been prepared for treating such cases. These combined (mixed) vaccines contain combinations of those organisms which have been found most frequently associated in producing or aggravating such diseased conditions. Very often, where treatment with a single vaccine produces little or no result, the use of a combined (mixed) vaccine is followed by very striking and positive results.

Method of Administration.—Bacterial vaccines are administered subcutaneously by means of an ordinary hypodermic syringe; the instrument must be properly sterilized, preferably by boiling, or by repeatedly washing it out with 5 per cent phenol solution—the needle must also be cleansed internally and externally by the same means—and the instrument should finally be rinsed out with boiled water.

The injections may be made in the region of the shoulder blade, in the arm at the insertion of the deltoid muscle; in the gluteal region; in the abdominal wall—in short, at any point where there is sufficient subcutaneous tissue, preference being given to the region in which the injection will produce the least pain or discomfort. At the point of injection the skin may be painted with iodine or cleansed with soap and water and mopped with alcohol. Any air contained in the syringe should be expelled before injecting the vaccine. After the operation the site of injection may be protected with a sterile gauze dressing, or may be wiped with a pledget of cotton moistened with alcohol.

The container should be well shaken before using the vaccine in order to suspend any bacteria that may have settled out on standing.

The amount of vaccine required varies according to the age and personal characteristics of the patient; the type, duration, extent, and severity of the infection, and the identity of the organisms. When the general condition of the patient is good, the response to the vaccine is more effective; hence, it may be necessary to administer the vaccine every 24 hours or oftener to an extremely ill person, while every five days may suffice for a convalescent patient.

As a general rule the intervals between the doses in acute infection vary from one to two days. After the acute symptoms have subsided—as shown by a drop in the temperature and by other signs of improvement—the intervals may vary from two to five days. In subacute and chronic infections the

FILLING SYRINGES WITH ANTITOXIN

Every precaution is taken to avoid contamination. Sterile caps and gowns are worn and even the air supplied to the room is washed and purified.

vaccine should be given every three to seven days, the doses being increased according to the clinical symptoms.

ANTIBACTERIAL SERUMS

Serums vs. Vaccines.—Immune seriums are fluids containing antibodies already formed and are injected into the circulation to supply antibacterial elements without stimulating the body cells to the production of these substances. Hence, in the use of seriums, the antibodies formed by the body cells of the horse or some other animal are supplied to the patient, and a condition of *passive immunity is established* lasting only a few weeks. This is how serums differ from bacterial vaccines: the latter confer active immunity, which in some cases may last for a number of years. Moreover, bacterial vaccines do not contain antibodies; their therapeutic value depends upon their stimulating action on the body cells of the patient, thereby producing various antibodies.

It requires an appreciable amount of time for antibodies to be formed after the bacterial vaccines are infected. Therefore, an immediate immunity does not follow; but, after it is established, the immunity persists for a long period.

It is probable, however, that the formation of immune bodies begins very shortly after the injection is made. On the other hand, the immunity conferred by an antitoxic or an antibacterial serum begins *at once*. If the serum is injected intravenously the entire content of immune bodies is at once available; if the serum is injected subcutaneously or intramuscularly, the immune bodies are available as rapidly as the serum is absorbed. As soon as the serum reaches the circulation the process of elimination is begun and proceeds rapidly; so that within a few days it is hard to discover immune bodies.

Definition.—Serums containing substances which result in the death and destruction of bacteria are called antibacterial serums. Acquired antibacterial immunity depends on the destruction of bacteria before they have had sufficient opportunity to multiply and produce poisons which kill the body cells. Various kinds of antibodies are found in the serums of animals that have acquired antibacterial immunity; the best known of these antibodies are bacteriolysins, opsonins, agglutinins, and precipitins. These prepared antibodies are introduced into the system of the individual by the injection of antibacterial serums which produce a condition of passive immunity.

Immune Serums.—There are two varieties of immune serums: (1) Antitoxic serums and (2) antibacterial serums. The former—represented by diphtheria antitoxin and tetanus antitoxin—neutralize the toxin in the circulation and in the various tissues and body cavities. In diphtheria and tetanus, the bacteria elaborate a poison or toxin which is absorbed into the circulating blood and is carried to the tissue cells, and this toxin must be rendered inert in order to effect a cure of the disease. The antibacterial serums, however, act directly upon the invading organisms and render them inert or destroy them, thereby arresting the disease.

ANTIBACTERIAL VS. ANTITOXIC SERUMS

Immune serums contain antibodies already formed. These antibodies in the antitoxic serums are chiefly antitoxins—substances which neutralize the bacterial poisons or toxins; while in the antibacterial serums the antibodies consist of bacteriolysins, agglutinins, precpiptins, opsonins, and other substances, all of which act directly upon the bacteria and tend to destroy them and their intracellular products.

Uses.—The practical application of specific antibacterial serums, in the treatment of various infections in man, has been used on a large scale. It has been found that by the *early* injection of serum from animals actively immunized to various organisms, the natural resistance of infected individuals can be augmented and the course of the disease materially ameliorated and shortened. Even in desperate cases, injections of large quantities of antibacterial serums have yielded most unexpectedly favorable results; while small doses, in similar cases, have usually been without beneficial action.

Antibacterial serums are preferably used when the disease is severe and the patient's resistance is low. Bacterial vaccines are also used in severe cases; but beneficial effects cannot be expected in as short a time from the use of bacterial vaccines as from antibacterial serums, since the latter contain

REMOVING SMALLPOX VACCINE FROM A VACCINATED CALF
The calves are killed before the vaccine is removed

antibodies already formed; while in the use of bacterial vaccines the body cells of the patient must first be acted upon and stimulated to the production of antibodies. This is necessarily a biologic process consuming a definite period of time, and in some cases it appears to be almost impossible to stimulate the body cells to the production of antibodies.

CONJOINT USE OF VACCINES AND SERUMS

If treatment is begun with the serum immune bodies are at once furnished; but, being contained in a foreign protein they are rapidly eliminated and in a few days only a trace of immune bodies can be detected. In order to establish a permanent immunity a vaccine may be used, and, if injected at about the same time as the serum, will stimulate the body cells of the patient to the production of antibodies which will maintain the immunity; so that the patient will be protected after the antibodies in the injected serum are eliminated.

Therapeutic Value.—The results of antibacterial serums in the treatment of diseases of man have, however, not always been as satisfactory as those obtained with specific antitoxin serums. The chief reasons for failure are:

(1) It is not possible to accumulate, in the serum of immunized animals, antibacterial elements in concentration which is at all comparable to the concentration of antitoxins in antitoxic serums.

(2) It has been impossible to adjust the dosage by any accurate unit of antibacterial elements and the doses which have generally been used have doubtless been too small to produce the desired favorable results.

Preparing Antibacterial Serums.—The usual method of preparing antibacterial serum is to inject gradually increasing doses of a vaccine and an autolysate (auto equals self; lysate equals a product of solution) made from cultures of a given micro-organism into healthy horses. These injections or inoculations of the vaccine and autolysate are made at frequent intervals and many different strains of the bacteria in question are used in preparing them. The vaccines are made in the way described above for preparing bacterial vaccines. To prepare the autolysates the living bacteria are placed in distilled water in an ice box (the temperature being 40 deg. fahr.) and allowed to extract for a week; sodium chloride is then added in the proportion of 9/10 of 1 per cent whereupon the solution is ready to be used for inoculating the horses.

The process of inoculation is contained in the best laboratories for several months. In the H. K. Mulford laboratory which supplied the serums employed by the American forces and to a large extent by their Allies during the war, the treatment is continued until the horses are "hyper humanized" which requires from 3 to 6 months' time. At one time so great was the need of these serums that these laboratories alone had over 1,000 horses undergoing treatment at once; the animals were kept in four groups of stables which were located in three different counties, so as to minimize the danger of loss by fire or other accidents.

SOME MALADIES TREATED BY SERUMS

The diseases to which serum treatment is applicable are various. Best known among these, of course, are smallpox and typhoid fever. Vaccination as a preventive of the former is now practically universal in all civilized countries—parents being required by law to have their children vaccinated at an early age, and the result of this wise ruling has been to practically stamp out the dread disease which formerly not only decimated the population of many countries but inflicted upon those of its victims who escaped death the almost more terrible curse of hideously marred visages. During the war the use of preventive vaccination for typhoid and para-typhoid fever was enormously extended. As a result of this practice our troops were almost entirely free of this disease, which even so recently as the Spanish war slew thousands of our men before they had a chance to set foot in Cuba.

The serum treatment of various eruptive and other skin diseases such as acne, boils, carbuncles, eczema, etc., is comparatively recent, but has already met with a good deal of success.

Diphtheria.—It is not many years ago that diphtheria was regarded as one of the most serious of menaces to children, particularly because of the rapidity of the growth of the bacillus. Thousands of lives have already been saved by the use of diphtheria antitoxin and the best authorities believe that many more cases could be saved by the prompt employment of large doses of this agent. When either children or adults have been exposed to diphtheria, the administration of 1,000 antitoxin units gives a protection which usually lasts 3 or 4 weeks, and is absolute for 10 days. However, the injection should be repeated at the end of two weeks if there is still danger of infection.

When a patient is actually suffering from the disease larger doses must be given, varying from 3,000 to 10,000 units in the early stages or mild cases, but running as high as 50,000 units in severe cases.

TREATING COMMON COLDS AND GRIP WITH SERUM

Recent studies of the almost universal periodic affliction of colds in the head or throat, influenza, etc., have shown that they are caused chiefly by bacteria—generally by several acting at once. The most common of these are the influenza bacillus, the Friedlander bacillus, the pneumococcus, the streptococcus, the staphylococcus, and the micrococcus catarrhalis. When for any reason the natural resistance of the mucous membrane is lowered, which may be the result of sitting in a draught, getting wet feet, going too long without food or sleep, etc., these pathogenic germs which are extremely prevalent hasten to take advantage of the temporary feebleness of their natural enemies and rapidly begin to grow in the mucous secretions which form an excellent medium for their development. These diseases are now frequently treated by a combined vaccine which is specially useful for administering in spring and fall to persons who are subject to frequent colds.

TECHNIQUE OF PREPARING SERUMS

As our pictures show, both the calf and the horse are employed for the production of serums. The calf is made use of, however, only in procuring serums for the milder kinds of maladies. Experiment and experience have shown that the horse is the most suitable of all animals for this purpose. To begin with it has a greater power of tolerance to disease germs, so that larger quantities can be administered and correspondingly it produces antibodies to check their baneful effect with great vigor. Cows and lambs are also occasionally used, but the horse is *par excellence* the source of the serums with which dangerous maladies such as pneumonia, diphtheria, tetanus, hydrophobia, typhoid and para-typhoid fevers are fought. One of man's best friends among the animal kingdom for untold ages, the horse, was never more so than now in spite of the rapidity with which he is being replaced as an agent of traffic by mechanical means.

Let us say to begin with that there is absolutely no cruelty and comparatively little pain involved in the procuring of the serum. Young, strong, healthy horses are employed and they are attended with the greatest care. When it is judged that the repeated doses of the given vaccine injected have raised the resisting power of the blood to a sufficiently high point, tests are made upon small animals, such as rabbits or guinea pigs. As we have said above the time required to produce a serum rich in antibodies, varies (partly according to the age of the horse) from 3 to 6 months.

When the appointed time has come for the animals to sacrifice not their own lives, but from 1 to 2 quarts of blood for the purpose of saving life, each animal is led out by a white robed attendant, as shown in our picture, carefully garbed so that all the conditions may be as safe as possible. The picture calls to mind a row of priests of ancient days ready to sacrifice the steeds of some great chieftain in order that their spirits might accompany him to the happy hunting grounds of the world

beyond. Our modern doctors are no less priests in their service to humanity, but the horse who sheds his blood at their merciful hands remains uninjured and soon recuperates.

The animals must, of course, be tied to prevent struggling, after which the blood is drawn directly from the jugular vein, the utmost care being taken that the operation shall be performed under aseptic conditions.

Technique of Preparation.—The first step is the removal of the blood corpuscles from the plasma. This reduces the amount to not more than one-half. From this there must be removed various substances such as water, mineral salts, etc. This is accomplished by filtering through charcoal in the presence of a weak oxidizing agent. The water is taken out not by heat but by chemical means, *i.e.*, by a drying agent such as lime. When the process is complete it is usually the case that only a few ounces, 4 or 5, of the precious antibodies remain from the original quart of blood.

Standardization.—The next step is standardization, *i.e.*, the determination of the exact therapeutic activity and antibody content of the serum. The method varies somewhat in different laboratories. In brief, we may say standardization includes the estimation of the opsonic index, the complement fixation test and similar immune serum tests. The serum is also subjected to very rigid bacteriological and physiological tests to make sure that it is absolutely sterile. When the finished product is found to meet the required standard, it is at once divided into small doses, usually about 15 minims each, and confined in vials known to the trade as ampoules. They are then placed in an ordinary ice box where they are kept until ready for use. Under no circumstances, however, are they kept for more than a year.

SERUMS FOR ANIMALS

Not only human beings but animals themselves profit by serums as a protection from disease. In the last few years these have been extensively used among farmers and breeders to check the spread of various pests among animals.

Rabies.—Perhaps a typical example may be found in rabies. The earliest reference to this disease was made by Aristotle in the fourth century B.C. While all warm-blooded animals are subject to this terrible acute disease, which was not long ago thought inevitably and rapidly fatal, it is the dog, another of man's best friends, which is most frequently infected and which is usually responsible for the transmission of the disease to human beings or to other domestic animals. The United States is said to have more cases of rabies than any other nation in the world except Italy. In 1912, there were more than 4,000 cases in this country. It is worth noting that there has not been a single case in England since 1902, when the muzzling law went into effect, while Australia has never had a case because of its admirable quarantine laws for animals. The virus is transmitted from an infected animal to a sound one by the saliva of the former, hence it is usually the effect of a bite. The period of incubation varies from 10 days to 6 months, or even longer, and the bite, which may in fact have been a mere scratch, may be entirely healed before the dreadful symptoms make their appearance. These symptoms are of two clinical types, the *excited* and the *paralytic*. It is very important that early symptoms should be recognized since the bite of a dog may communicate the disease from 3 to 5 days before the animal seems to be seriously affected. At this time the animal may be unusually playful and affectionate, but later there is a striking change in the voice which becomes a hoarse howl followed by irregular barks of lower pitch than normal. The poor "mad dog" becomes restless and irritable and may suddenly leave home wandering off for many miles and coming back utterly changed. He does not fight other dogs but bites them and passes on; then swallowing becomes difficult or impossible and convulsions appear. The animal may die in one of these. Generally, however, paralysis comes first.

The *paralytic* form is even more dangerous to the owner than the excited form described above, since the owner may merely suppose that the dog is suffering from a bone in its throat and be bitten upon endeavoring to remove it. The poor creatures are intensely thirsty and wish to drink but are unable to swallow when the muscles of the throat become paralyzed.

Treatment.—Anti-rabic treatment is useful during the incubation period but not afterward. This treatment consists of the injection of 25 doses of rabies vaccine given daily for 21 successive days.

How Bivalves Feed

Effect of Ions Upon the Movements of Cilia

MANY investigators in recent years have studied the vibratory motions of cilia and the modification produced by one or another form of alternation in the medium which surrounds the animal which bears them. The question is obviously of great importance with respect to those edible bivalves of various sorts, which furnish so large a proportion of our food and which obtain their own food supply from the minute creatures, drawn within their reach by the waving motion of the cilia upon their gills.

The results of some recent investigations in this line have been published by Mr. J. Gray, M.A., a fellow of King's College, Cambridge, which add much to our knowledge of the conditions requisite for the proper functioning of such cilia. The special material chosen for study was the gills of the *Mytilus edulis*, or edible mussel, a well-known commercial shell fish. The main current of water drawn into the gills is caused by the lateral cilia, which are very numerous since each cell of the epithelium bears several cilia. The most characteristic feature of their normal movement is a wave or pulsation which passes up one side of the filament and down on the other. The lateral frontal cilia are used for straining and assist in passing food from the main current on to the frontal cilia, which in their turn pass the food down the face of the gill on to the ciliated terminal groove. The cilia of this groove move in such a manner as to direct the food toward the mouth in a long line of mucus. Mr. Gray selected the latero-frontal and terminal cilia to study the effects of various ions with respect to their motion. His studies comprised two objects: 1. An inquiry as to the action of various ions upon the activity of individual ciliated cells—*i.e.*, upon ciliary movement as such, and 2, the action of certain ions upon the tissue complex. Writing in the *Quarterly Journal of Microscopical Science* (London), March, 1920, he says with regard to this point: "The absence of certain ions results in the break up of the ciliated epithelium into its constituent cells, although the cilia of the individual cells continue to beat strongly when the cells are entirely detached from the gill and from other cells. It is only in the case of the hydrogen-ion that direct action upon ciliary movements can be studied without injury to the general structure of the gill."

The sea water used by Mr. Gray was obtained from the English Channel, some miles south of Plymouth, and throughout the experiments the hydrogen ion concentration was constant, being about 7.85.

One of the first things noticed was that when this concentration fell below 6 the cilia very soon stopped moving. However, the ciliated epithelium did not break up and when the concentration of hydrogen ions was increased the cilia began to move again.

Mr. Gray studied the effects upon the ciliary motion exerted

by acids, by alkalis, and by neutral solutions. Some of his most interesting experiments had to do with the result of the metallic ions present in sea water. We give a summary of his observations upon this point.

EFFECTS OF METALLIC IONS IN SEA WATER

As far as the action of metallic ions is concerned the most definite point established is that an efficient physiological solution must contain sodium, potassium, magnesium and calcium. In such a solution, whose hydrogen ion concentration is identical with sea water, gill-filaments will remain healthy and exhibit active ciliary movement for more than five days. If any one ion be omitted from the solution, the ciliated epithelium exhibits signs of disintegration after some hours, and the tissue gradually breaks up, although some cilia may continue to beat for as long as three days. If two ions are omitted, the duration of active ciliary movement is from sixteen to twenty-four hours, but the phenomenon of disintegration is very marked. Finally, in solutions containing only one metallic ion, disintegration rapidly sets in and the tissue is very unhealthy after twelve hours; also ciliary movement is usually markedly affected in less than two hours.

than tertiary mixtures, while solutions containing Na, K, Mg and Ca form satisfactory physiological solutions.

SUMMARY OF RESULTS

(1) With the exception of the wave action of the lateral cilia isolated fragments of the gills of *Mytilus* continue to function normally in sea water for many days.

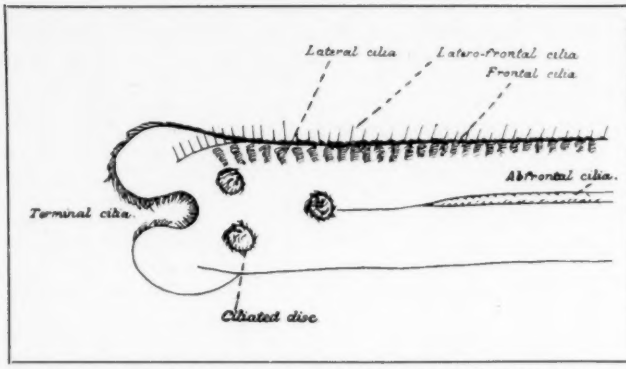


FIG. 1. LATERAL VIEW OF A LIVING FILAMENT OF THE GILL OF *MYTILUS EDULIS* (AFTER ORTON)

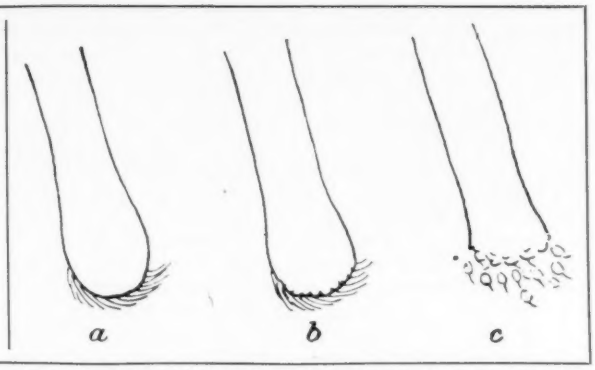


FIG. 4 . PROGRESSIVE DISINTEGRATION OF THE TERMINAL CILIATED EPITHELIUM IN PURE SODIUM CHLORIDE

(2) Ciliary activity is dependent upon a certain minimal concentration of hydroxyl-ions.

(3) Stoppage of the cilia by acid is reversible by raising the hydrogen content by means of an alkali.

(4) If the hydrogen ion content of the medium is above 9.0 the ciliated epithelium rapidly breaks up into its constituent cells, but ciliary movement does not stop either in the isolated cells or in those which remain *in situ*.

(5) The breaking up or disintegration of the ciliated epithelium takes place in all solutions which do not contain potassium, sodium, magnesium and calcium.

(6) Solutions containing only one metallic ion are highly toxic to the tissue, causing marked disintegration even at low values of the hydrogen ion content. Solutions containing two ions are less detrimental than solutions containing only one.

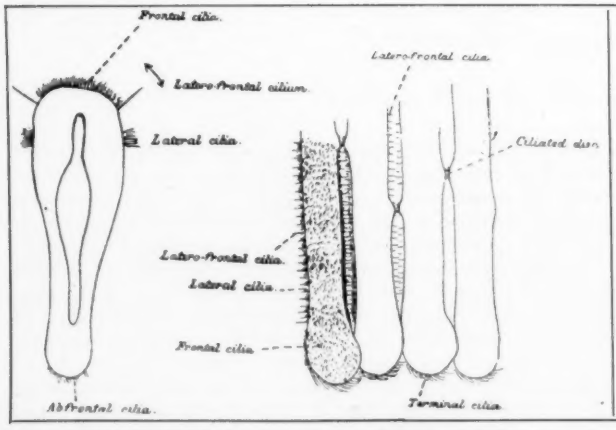


FIG. 2. TRANSVERSE SECTION OF GILL-FILAMENT OF MYTILUS

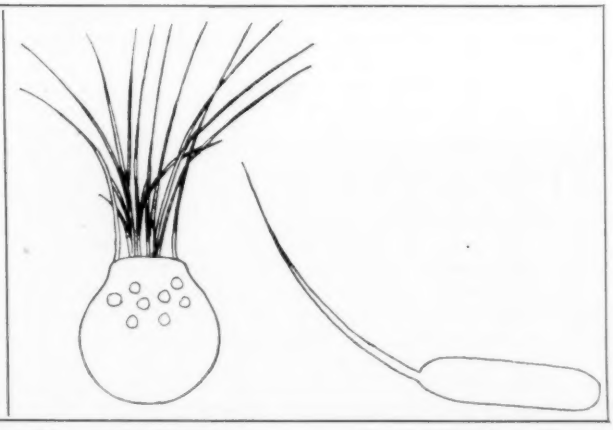


FIG. 3. VERTICAL VIEW OF GILL-FILAMENTS OF MYTILUS

FIG. 5. SINGLE CELL OF LATERAL CILIATED EPITHELIUM

FIG. 6. VIEW OF A SINGLE DETACHED LATERAL CILIUM

It will be noted that very little evidence is obtained on the qualitative value of any particular metallic ion. Sodium appears to be more toxic than potassium. The presence of excess of calcium appears to cause separation of the gill-filaments, and it is possible, therefore, that this ion affects the ciliated junctions or discs. No clear evidence is obtained of antagonistic action between ions; the action of the various metals appears to be additive. Solutions of pure salts are more toxic than binary mixtures, binary mixtures more toxic Solutions containing three ions support the tissue in a comparatively healthy state for as much as seventy-two hours; but it is only when the four metallic ions are present that the tissue remains normal and healthy as in sea water.

(7) Little evidence was obtained of qualitative effects of single metallic ions or of antagonistic ion action.

(8) Attention is drawn to the necessity of controlling the hydrogen-ion concentration in all solutions used in the investigation of antagonistic ion action.

Foods Under the Microscope

Some Interesting and Significant Results of the Ocular Analysis of Alimental Substances

By Leon Augustus Hausman, Ph.D., Cornell University

BY means of the unassisted eye alone it is possible, as we all know, to recognize gross structural differences between large fragments of animal and vegetable substances, and to refer them to their proper sources. When, however, such materials are finely ground or pulverized, or made into what seem almost homogeneous pastes, or cakes, then the problem of determining the sources of their constituent materials becomes a different one. And yet, it is not different in principle, but only in kind, for we still use the eye as the chief means of analysis, but with its ocular power enormously increased by the aid of the compound microscope. Through this powerful instrument most substances can be seen to be what they really are, and can be made to yield up the secrets of their derivation. There are but a meager number of foods (liquids of course, excepted) which may not be analyzed by means of the microscope. The presence of extremely minute quantities of a substance may be detected in admixtures, apparently of perfect purity. Thus one part of turmeric has been detected in 448 parts of mustard! Again, from the size, shape, and structure of the pollen grains within a sample of honey it is possible for the microscopist to determine the sorts of flowers which have yielded the original nectar to the bees; and, furthermore, from the form and structure of the crystals in the mass, to say whether the honey has been adulterated with sugar, and to what extent. The field of analysis over which the use of the microscope can be extended by the well-trained scientist is surprisingly broad, and its boundaries are constantly widening. Almost without exception, any substance, save a clear pure liquid, when properly prepared for and examined under the microscope, will render up to the observer the secrets of its original source or sources. Furthermore, by the examination of accurately known quantities of a substance containing adulteratives, the percentages of the various substances present can be accurately stated. This was recently brought out clearly by a series of examinations by the author of samples of different flours where the starch grains could be counted, much as blood corpuscles are counted by the physiologist.

In many cases, of course, the examination of food and other substances requires preparation, and special methods of utilizing the microscope and its accessories. There are many others, however, in which comparatively simple manipulation is sufficient. In Fig. 1 is shown the author's equipment for the examination of substances by means of transmitted light, *i.e.*, light thrown up *through* the substance under examination, which is placed on a glass slide on the stage (B) of the microscope, by the microscope mirror (E). The light is obtained from the lamp (A). Such a method of illuminating is used for starch grains, and similar objects which are transparent or translucent. The substance on the slide is often mounted in water, alcohol, xylol, glycerine, Canada balsam, celloidin, or in various microscopical oils, and is covered with a coverglass.

Fig. 2 shows the microscope arranged for examination of substances which are opaque or nearly so. In this instance the light which travels up the microscope tube to the eye of the observer cannot pass *through* the object on the stage, but must be reflected upward from its surface by a source of illumination placed above. These are the two primary ways of lighting objects for examination under the microscope. Many modifications of these two fundamental methods of illumination exist, demanding special apparatus. Upon trial, it will be discovered that each substance requires its own special manipulation of preparation, illumination, and magnification to secure the best results.

With the ordinary compound microscope two objectives (B, Fig. 2) called the 16 millimeter and the 4 millimeter; and one ocular (O, Fig. 1) usually the 8 times, or 8 power, will afford sufficiently great magnification for analytical work.

An indispensable piece of apparatus for those wishing to do accurate work in identification, particularly of substances which closely resemble one another, is the comparison ocular. This is fitted to two microscopes, as shown in Fig. 3, in such a way that the two samples under observation reflect their images into the single ocular; each microscope, that is, exhibiting half of its circular field to the eye of the observer.

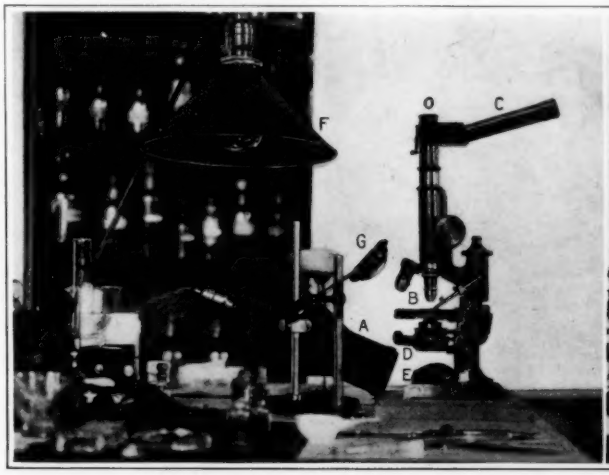


FIG. 1. MICROSCOPE ARRANGED FOR EXAMINATION OF SUBSTANCES BY TRANSMITTED LIGHT

Light from lamp (A) reflected by mirror (E) passes up through the specimen on the stage (B) and thence up the body tube to the eye, at the ocular (O). The extension ocular (C) prevents the necessity of craning one's neck over the ocular.

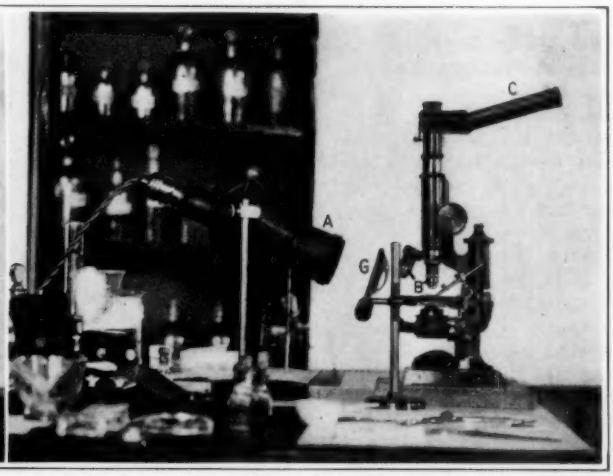


FIG. 2. EQUIPMENT FOR EXAMINING SUBSTANCES THAT ARE OPAQUE OR NEARLY SO

The lamp (A) has been elevated above the level of the stage, and its light is focussed on the object by the condensing lens (G). The sub-stage mirror has been turned aside so that no light from it enters the microscope tube.

Thus two preparations, on slides, can be enlarged to equal magnitudes and brought close together for intimate and detailed comparison within the same microscopic field. The utility of such a device will be at once apparent. Figs. 17, 18 and 21 to 24 were all made from such a comparison ocular.

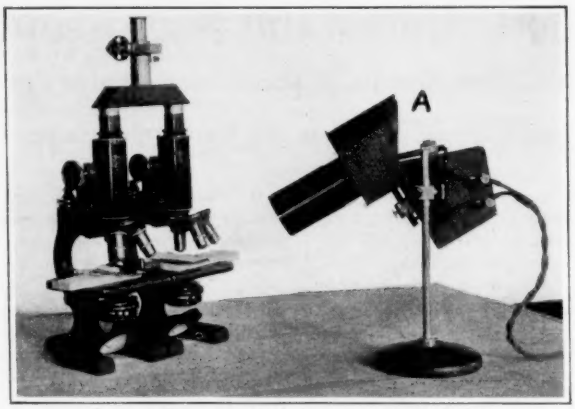


FIG. 3. TWO MICROSCOPES FITTED WITH A COMPARISON OCULAR

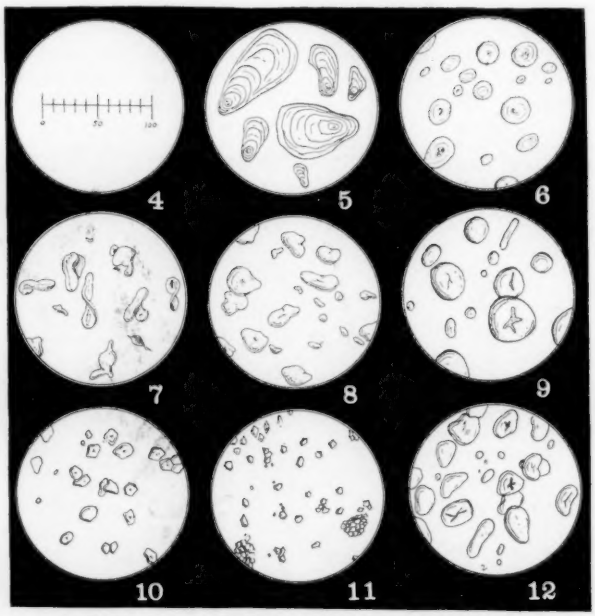
The ocular itself contains a scale for delicate measurements. (See Fig. 4.) The objects undergoing comparison are being viewed by reflected light thrown from the arc lamp (A).

The microscopist who is called upon to examine and pronounce upon the constituents of a great number of diverse substances must have a fundamental knowledge, at least, of the appearance of the various basic animal and plant tissues. Some knowledge of botany is here presupposed, as well as of zoology, and the form and structure of certain crystals of chemical substances. The comparison ocular often makes easy the identification of unknown fibers, cells, or crystals. In some papers of recent publication, the author has pointed out also how a knowledge of the microscopic structure in the hair of the fur-bearing mammals can be used to identify the species of mammal from which the hair was derived, and in this way to detect imitations.

One of the most important substances from the food point of view is starch. It is one of the most widely distributed elements in the content of plant cells. Careful researches by botanists have shown that the starch grains of any particular plant are characteristic of that plant in shape, size, and structures of various sorts. Thus each plant bears its own characteristics in its starch grains, and these may therefore indicate their origin. The value of such differences in starch grains to the microscopist is apparent. Since starch grains are present so universally in vegetable substances, it is almost impossible to include, in a food preparation any vegetable substance, without including also its tell-tale starch granules. And if, by chance, or design, some portion of any plant is used (such as the husk, etc.), where starch grains may not be present, the structure of the cells of which the tissue is composed can be just as readily used as a basis for identification. An eminent microscopist recently remarked to the author: "Very few secrets, dealing with the composition of material things, are safely hidden from the man with a microscope."

Fig. 5 shows the appearance, under transmitted light, of a very common starch, potato starch, which is all too common as an adulterant of many kinds of foods. The grain is usually described as resembling an oyster shell, and surely a better simile could not be found. In this, as in many other starches, the grains vary much in size, but whatever their magnitudes, their characteristic form and markings remain constant. It is the characteristics of the form and the structure which the microscopist looks for, in identifying starches, rather than for size. However, the *average* sizes of starch grains from different plants (or different parts of the same plant) can be compared, often with results of value in establishing, or supporting, identities or differences. In Fig. 16 is shown a sample of a soluble cocoa, which, it can be seen, is mixed with potato flour. Since this is a typical sample taken from the well-mixed "cocoa" the true proportions of the pure cocoa and the potato flour can be inferred. Notice that the cells, composing the cotyledons, or parts of the cocoa seed, are as large as the potato-starch grains themselves, and that the cocoa-starch grains are very minute. Such an enormous adulteration of the cocoa with potato could not, by any other means than microscopical examination, be so easily detected. Fig. 22 again, shows another easily adulterated food, or rather condiment, ginger, which is often mixed with potato- and sago-starches.

The question has often been asked whether it is possible to distinguish between food substances which have undergone the process of cooking, in various ways. In most cases, yes. Heat, either moist or dry, affects starch grains, as well as other vegetable and animal substances in different ways, and the identification of such modified substances is merely a matter of study. For example, compare Figs. 6, 7 and 8. Fig. 6 shows raw wheat starch as it can be seen in flour. Fig. 7 shows the appearance of the starch grains after having been boiled, *i.e.*, as in puddings; and Fig. 8 their appearance after having been baked, as in bread or cake. In dry heat the grains simply split up, but in any preparation except one completely charred into carbon, retain enough of their "personalities" to be recognizable. In wheat starch, the raw grains are discoidal, with the flat faces bearing an almost circular outline (Fig. 6). The striations are absent, or nearly so, and the grain appears as though made of a glassy substance. Wheat flour is often substituted by, or largely adulterated with, potato flour. The detection, of course, is simple.



FIGS. 4-12—A STUDY OF STARCH GRANULES

4, Scale for comparing sizes of starch granules. Such a scale is placed in the ocular of the microscope. 5, Potato Starch. 6, Wheat starch (raw). 7, Wheat starch (boiled). 8, Wheat starch (baked). 9, Rye starch. 10, Corn starch. 11, Rice starch. 12, Bean starch.

The starch granules of rye, as seen in the rye flour (Fig. 9) closely resemble those of wheat. Here is a case where careful study has to be made, and measurements taken with apparatus specially designed

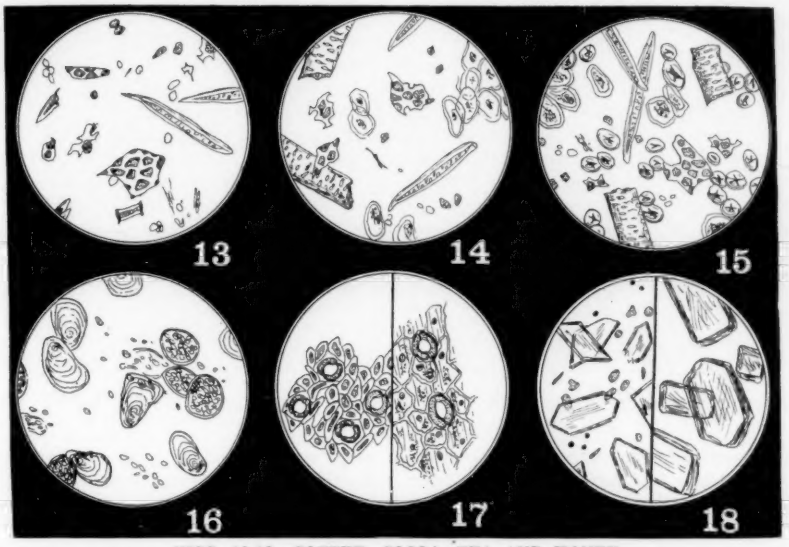
for minute measurements under the microscope. The use of the comparison ocular is in such cases a necessity of indubitable identifications are to be made.

In corn flour the characteristic form of the starch granules at once proclaims their origin, being slightly polygonal in form, with rounded angles (Fig. 10). A central depression is present in most of the grains.

Fig. 11 shows the appearance of the starch granules of rice flour. Here the individual grains are distinctly polygonal, with sharp angles and edges, many of them being irregularly pentagonal. Like the starch grains of oats, they are often found coalesced into larger compound grains. From oat starch, rice starch is to be distinguished by the smaller size of its individual granules.

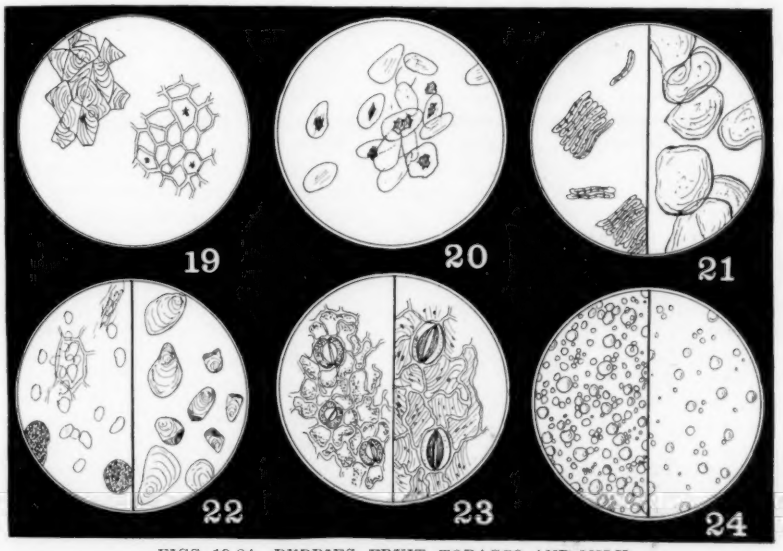
Bean flour is often, like potato and barley flour, used as a substitute for, or an adulterant of, wheat flour. Fig. 12 depicts the appearance of the bean-flour starch grains. Beans of different varieties, show corresponding differences in their starch grains, but in general, the large likeness between bean starches of all sorts was early recognized.

Coffees are among the food materials most largely adulterated, and here the microscope is an invaluable aid in detecting at once the presence among the coffee-bean fragments, parts of other vegetable substances. No starch is present in the coffee bean, but other characteristic structures are there which serve as guides to identification. In Fig. 13 we have the appearance of roasted and ground coffee. The most characteristic portions of the bean structure are the dark, angular cells forming the interior substance of the bean itself (endosperm). These fracture irregularly, as shown. In the unroasted coffee there are present in each of these cells several oil globules, but these are driven off by the heat during the process of roasting. The long, fusiform cells of the outer investiture of the coffee-bean are also present in the prepared coffee. Compare now the sample shown in Fig. 14. Here there has been added to the coffee, chicory, which though roasted and ground with the coffee and thoroughly admixed still reveals its presence unerringly, through the characters of its cells. The extraneous matter in this sample can be seen by comparing it with Fig. 13. In Fig. 15 is shown still another "coffee" adulterated still more by the addition not only of chicory but also of ground and roasted acorns. The element proclaiming indubitably the presence of the latter adulterant is the starch granules, with their characteristic stellate black figure in their centers, an appearance due to the way in which each grain diffuses the light from the microscope mirror. The degree of adulteration of this particular sample can be estimated with fair accuracy from the multitude of acorn-starch grains.



FIGS. 13-18—COFFEE, COCOA, TEA AND HONEY

13. Roasted ground coffee. 14. Coffee and chicory. 15. Coffee, chicory and acorn. 16. Cocoa and potato starch. 17. *Left*: lower epidermis of tea leaf. *Right*: lower epidermis of plum leaf. 18. *Left*: honey. *Right*: sugar.



FIGS. 19-24—BERRIES, FRUIT, TOBACCO AND MILK

19. Strawberry. 20. Cherry. 21. *Left*: red currant. *Right*: apple and turnip cells. 22. *Left*: ginger. *Right*: sago and potato starches. 23. *Left*: lower epidermis of tobacco. *Right*: lower epidermis of rhubarb. 24. *Left*: rich milk. *Right*: poor or diluted milk.

Tea also has its adulterants (as what food does not!), and here again detection is not difficult. The detection of leaf adulterants in tea is based largely upon the differences in the character of the epidermis, or "skin" of the leaf. In the lower epidermis, especially, comparison is easy, for this lower integument of all leaves which are associated with tea as adulterants, bears large guard-cells surrounding the stomata, or breathing pores in the leaf. These, together with the shape of the cells of the lower epidermis itself, offer almost infallible indices to the species of plant from which the leaf was derived. In Fig. 17 are shown two specimens of lower epidermis of leaves, brought together for accurate comparison by means of the comparison ocular (Fig. 3). The left epidermis is that from the common china tea (Camellia), while the right specimen is from the leaf of a plum, found in a sample sold as strictly pure tea. The difference is obvious, and the detection simple.

Figure 18 shows another interesting and significant comparison (through the comparison ocular), that of the crystals of

honey (left sample) and of cane sugar (right sample). Honey may be adulterated with cane sugar, as well as with various starches. In any case the clear cut honey-crystals serve for differentiation. Note how large and massive are the sugar crystals. Within honey samples there are found the pollen grains from the various flowers visited by the bees.

Preserved fruits in the forms of jams, marmalade, etc., are easily analyzed under the microscope, for here the various structures of the pulp and skins of the fruits used can be readily spread out upon the microscope slides, and identifications made by means of the comparison ocular. Fig. 19 shows characteristic structures in the strawberry, as seen in the fruit after it has been made into jam, and Fig. 20, of the cherry. Turnip and apple are commonly used as adulterants in all sorts of fruit preserves. In Fig. 21 is depicted the appearance (on the right) of the large, bulky cells of the pulp of the apple (below), and of the turnip (above). On the left are cells from the red currant, as they appear in jams.

Tobacco adulteration offers another fertile field for the operations of the dispenser of adulterated commodities. Many varieties of leaves are used to dilute ground tobaccoes, or tobaccoes sold for manufacture into cigars. These may be distinguished by the microscope on the basis of their different cell structure. In Fig. 23 is shown, on the left, the lower epidermis of the tobacco leaf; and on the right the lower epidermis of the rhubarb leaf, commonly detectable in some varieties of tobacco. Note how readily the shape of the crescentric cells (guard-cells) surrounding the stomata or breathing pores of the leaf, can be used as distinguishing features.

Not only can the microscope be used to detect admixtures of extraneous matters into any given pure substance, but also to determine the comparative richness of certain elements in various foods. Thus milk samples can be readily graded, care being taken to estimate the number of fat globules present in a given amount. Fig. 24 shows, on the left, a sample of full rich milk, and on the right a sample of poor, or diluted milk. In the latter case see how the paucity of fat globules tells a tale of inferiority which might not be capable of determination except through the use of much less expeditious procedure than examination in the microscope.

The first test of many substances should always be the microscopic one. In most cases no other will be necessary.

Searching the World for New Food Plants

A 9,000-Mile Trip Through Africa in Quest of New Fruits, Nut Plants and Forage Crops

DR. H. L. SHANTZ, a government botanist, has recently returned from a 9,000-mile trip through darkest Africa, the purpose of which was to study the native agriculture with an eye for new fruits, nut plants, forage crops, especially those adapted to our South and West, new sorghums and especially wild sorghum grasses of types similar to Sudan grass. This grass has proved such an important forage crop in the semi-arid districts of the western part of the United States that ten million dollars' worth of it was grown last year.

Dr. Shantz and Mr. Reval, of the Smithsonian Institution, made the acquaintance of many agriculturists and men in various sections of the Dark Continent who can in the future be useful to the department by sending in plants which are desirable and which could not otherwise be obtained. The direct tangible results consist of seeds or living material of more than 1,600 different species or varieties of plants, many of which had not previously been imported into the United States, and from which it is only reasonable to suppose some important grain, forage or fruit crops may be developed.

The party sailed directly to the Cape Verde Islands off the coast of Africa, and from there to Cape Town. The journey of nearly 9,000 miles was made almost entirely through the heart of Africa, sometimes 1,000 miles inland, with occasional expeditions to the coast for observations of Zanzibar and other islands, and at Lourenco Marques and Beira.

In Cape Colony, Dr. Shantz went east to Port Elizabeth, where the famous Addo bush is found. He obtained many plants, one of the most interesting being the Speckboom, one of the most important foods of the elephant. This plant covers whole hillsides with its succulent growth. Cattle and sheep are fond of it, and there is a chance of its becoming of value in southern California. Speckboom will grow under practically the same conditions as the utterly worthless chaparral of southwestern California.

THE EXPEDITION GOING INTO CAMP ON THE KAFUE RIVER IN NORTHERN RHODESIA—A REGION RICH IN NATIVE FRUITS

The explorer then passed northwest over the Karroo desert, similar to ours in the Great Basin, but differing in that most of the plants form excellent forage for sheep, cattle, and ostriches, and it seems probable that some of the more desirable of these desert plants may be utilized in our desert country to improve the range.

The route lay east and north through the Kimberley diamond region and the gold mining country of Johannesburg and Pretoria, the capital of the Union of South Africa.

Much of the country which Livingstone painfully traversed something more than half a century ago, is now open to the traveler with comparative comfort, if he rides on the South African railway. There are still fastnesses, however, where the party was compelled to tramp as much as 800 miles away from any railways. The route often lay through the jungle, where there are no roads at all.

Long stretches were covered by steamer, many of them belonging to primitive transportation systems where the traveler is required not only to buy passage, but also to provide himself with bed, shelter, food, and even the wood with which to cook it.

In the center of the great Transvaal agricultural area corn, known as mealies, is the chief crop. Dr. Shantz, to his surprise, came upon one of the most important varieties, our own Boone County White, a gift from America of considerable value to the farmers of the Transvaal. It was like meeting a friend from home.

In the low veldt at Nelspruit are large orchards of subtropical trees and fruits, many varieties of which have not been grown in the United States. Among them are some particularly desirable mangoes, adaptable to Florida, which the Department has wanted for several years.

The party traveled over

WILD COTTON IN THE UPPER SUDAN

This was the basis of our American-Egyptian cotton which produces a $20,000,000 annual crop in regions not formerly arable

A FIELD OF NATIVE AFRICAN SORGHUM GRASS

It was from such a source that the United States Department of Agriculture brought the seed which has developed an industry worth many million dollars a year on semi-arid soil of the Southwest.

the highlands of Portuguese East Africa, which have been developed by the Mozambique company into one of the most important agricultural sections of East Africa. It proceeded across Southern Rhodesia to Bulowayo and Victoria Falls. At the latter point many of the fruits concerning which Livingstone wrote enthusiastically, were found and tasted. The modern Livingstone sent the seeds to the Department of Agriculture in the hope that they might prove useful in this country.

Dr. Shantz spent a month at Kafue in the north of Northern Rhodesia, where a delay was caused by the sickness of two members of the party. Word was received of a railway wreck on the Congo railway, in which two members of the original party were killed and two injured and forced to return to America. This news, coupled with the sickness in camp, was the darkest part of the trip and threatened at one time to terminate the expedition, so far as Central Africa was concerned.

In spite of the hardships, the party decided to keep on through the Congo. Here for the first time the men encountered a lack of adequate provision for traveling. Practically no accommodations and no provision for food for travelers were found, although in some cases the captains on the ships on the Congo were kind enough to allow the travelers to mess with them. At certain points grass huts had been provided as temporary quarters.

In Zanzibar, principally noted for the production of cloves and for the extensive groves of cocoanut palm and many tropical and sub-tropical plants, Dr. Shantz obtained and sent home seeds and plants of a number of important fruits. He also collected samples of the staple grains and legumes grown in various parts of the East Coast of Africa which are brought

STEAMER ON THE NILE USED DURING THE TRIP THROUGH AFRICA

in by the natives and sold in the Zanzibar market places.

The explorer made an extensive trip into the desert country north and east of Mt. Kenia, and collected the principal varieties of tropical crops grown by the natives in this section. Here he also obtained a notable nut plant called telfairia, which forms a large gourd two or three feet long containing many seeds of a delicious nutty flavor, about one inch in diameter and one-quarter of an inch through, and which tastes something like our butternut. Although this plant has not yet been tried in this country, it seems probable to the experts that it can be grown here or at least in the Philippines and possibly in Hawaii and Porto Rico as well.

Dr. Shantz brought with him about 3,000 photographs in addition to the many plant specimens. The living plant material is now growing in the various plant introduction gardens of the Department preparatory to being distributed later to experiment stations and experimenters in different parts of the country.

DR. SHANTZ, AT THE LEFT, PERCHED ON AN ELEPHANT KILLED NEAR THE CAMP AT PORT ELIZABETH, CAPE COLONY

AN "OVEN PLANT"

THE wild flower known as cuckoo-print (Arum maculatum) may be regarded as a sort of oven plant. It lives in damp and shady deciduous forests and blooms in early spring, while the sun is still able to penetrate the bare branches. The blossom, or rather the club like support of the flowers, consists of a greenish white protecting leaf, wide open at the top but coming together in a pot like shape at the bottom. Beneath the club-shaped portion of the spadix are several rows of stiff hairs extending to the wall of the closed portion of the enclosing bract forming a sort of net beneath which are several stamens and the pistil. Pollination of the pistil is accomplished by insects which pass through the thicket of hairs into the kettle-shaped portion of the flower but do not get out again at once. Within this space there is a higher temperature than without on account of the livelier respiration of the plant. The greater warmth of the spadix can even be felt when the tongue is placed against it. In some species, indeed, difference of temperature is actually as much as from 10 to 20° C. higher.

The numerous little gnats which have gained an entrance through the forest of hairs to this comfortably heated apartment, remain captive for a few days, regaling themselves meanwhile with the drops of honey spread before them and later, with the flowery pollen which has ripened in their efforts to get this they accomplish their destined purpose of fertilizing the pistil and now find themselves free to depart, since the surrounding hairs which hitherto prevented them from escaping have shriveled away.

PAPER FABRICS AGAIN

DURING the war a great deal was heard of the use to which Germans were putting paper including paper bandages which proved to be strong and pliable enough for the purpose, paper clothing, some of which later appeared in other markets, and a variety of cloths particularly useful in taking the place of coarse fabrics. German woven paper bags and sacks are beginning to make their appearance in England in considerable quantities and there seems to be no doubt of their strength and general utility. They are reported to be clean, well made and of light weight, and are scarcely distinguishable from jute.

INSPECTING A BANANA SHAMBA IN THE UPPER BELGIAN CONGO

Possibly some of these may be found resistant to the banana disease. Seed of a wild banana adapted to ornamental purpose, were brought in by the explorer. Because of the remoteness of the region to have brought banana shoots would have required a special expedition.

Flavors, Odors and Infra-Red Rays*

Measuring Degrees of Taste and Smell with the Olfactometer and the Saporimeter

By G. Hamelin

OF all the senses possessed by animals, taste and smell are the most useful, for various reasons. In the first place they guide them in the search for food and in decision as to the latter's quality; furthermore, they control those important reflexes by means of which the digestive secretions, such as the saliva, the gastric juice, etc., are governed, and they augment the respiratory and muscular reflex actions. They appear to be in a rather retrograde condition in mankind: The human embryo, for example, has the so-called "taste buds" or papillae distributed as far as the opening to the oesophagus, just as fishes do. The fair sex, to be sure, finds perfumes attractive, and statistics show that there is a steady increase in the sale of toilet water, etc., and the sterner sex is still devoted to fine wines and tobaccos, despite the recent increase in their cost. We are still ignorant of the true nature of the factor which determines sapidity and odor. It is undeniably true that these qualities are connected with the emission of molecules of matter or ions, but to say this does not afford an explanation. For this reason I was greatly surprised to discover, in a treatise by M. Charles Henry, called *Rayonnement, Gravitation, Vie* (Radiation, Gravitation, Life) and published by The Institute of General Psychology, certain pages to which this title gives no clue and which carry with them an implication of a complete solution of the problem, since their author sets forth in them his calculations concerning the tastes and the odors of various sapid and fragrant bodies.

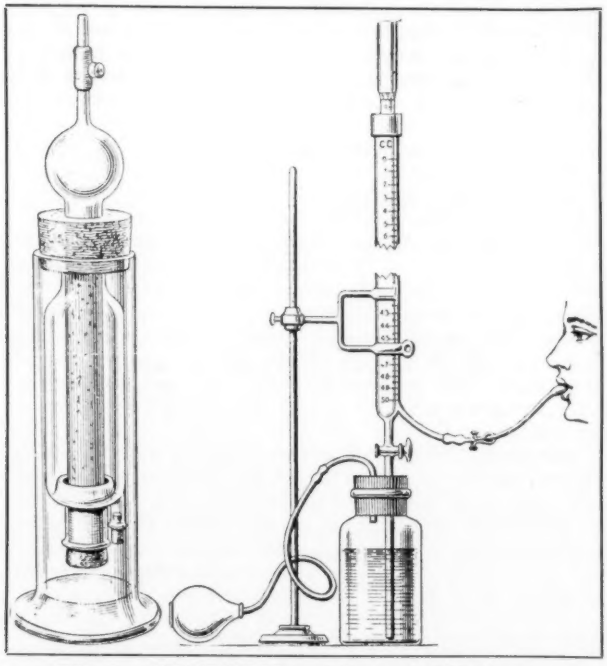


FIG. 1. OLFACTOMETER. FIG. 2. SAPORIMETER

The olfactometer is used to calculate the weights of the amounts of vapor which have passed in succession into the tube. This weight is the upper limit of the perceptible limit of an odorous liquid or solid body. The saporimeter is an apparatus employed for testing wines, beers, etc.

Hitherto this problem has been attacked only by physiological methods. Investigators have sought to measure the smallest perceptible degrees in taste and in smell, and to understand the psycho-physical laws concerned, *i.e.*, the relations between certain degrees of sensation and various concentrations of liquids or vapors, the times of reaction required, etc. This was indeed the only possible method of obtaining results, and this must necessarily be the starting point in any endeavor to determine the relations between these poorly understood senses and the better known ones of sight and sound. In order to measure the "perceptible minima" of odors and savors, M. Henry has invented his well-known olfactometer and saporimeter. The former (Fig. 1) consists of a glass vessel traversed by two tubes, one of which slides into the other: A paper tube stoppered at the bottom, and inside of this a glass tube gradated in millimeters, whose upper part emerges from the vessel so that it can be introduced into one nostril while the other is closed. In the vessel are placed a few drops of the odorous liquid to be examined; as soon as the atmosphere of the vessel is saturated it is closed by a test tube provided with a stop cock. The operator notes the time and then lifts the glass tube, being careful to have the movement proceed at a uniform rate; at the instant when the minimum sensation is produced he notes the time, and stops the motion of the glass tube. The weight of the vapor which has passed successively into the tube can be calculated by means of the height and duration of the lifting motion with the apparatus as a constant, and having also a knowledge of the rapidity of evaporation of the odorous body at the temperature of the experiment. This weight represents the upper limit of the perceptible minimum.

The rapidity of evaporation of the liquid at the temperature of the experiment is given by a vapor scale. This is an extremely sensitive aerometer whose nickel plated steel rod about 0.5 mm. in diameter, moves in a vessel containing alcohol along a scale divided in millimeters. This apparatus is so delicate that by its means it is possible to detect even the smallest adulteration in the composition of the perfume, provided the velocity of evaporation of the pure perfume is sufficiently well known.

I visited M. Henry who is the head of the Laboratory of the Physiology of Sensations at the Sorbonne, in order to request him to throw some light upon his discovery and give me some explanation of its origin. He called my attention to the fact that it had been quite easy to make an improvement in his olfactometer merely by replacing the movement of the tube by a photographic shutter or diagram, so arranged as to leave uncovered, for various known amounts of time, a variable and known area of paper; through this shutter there is allowed to pass at the maximum tension a minute quantity by weight of the odorous vapor to be examined; this fractional weight is the same for all vapors, an important fact which was quite unsuspected, but which has been indisputably established by experiment. In this manner it is possible to determine with absolute precision the perceptible minima of various odorous gases.

"This method of research," M. Henry remarked to me, "is all the more interesting, since the method ordinarily employed by many physiologists, which consists in diluting perfumes with alcohol and placing a drop of the mixture in a glass vessel, whose exact content is known, is quite incorrect. Such a method, moreover, is frequently found to give results which contradict those obtained by the comparative methods of Zwaardemaaker, which consists in uncovering known areas of a porous tube saturated with perfume. This latter process yields results absolutely in agreement with mine, making use, as is evident, of a device which closely resembles my own olfactometer, though founded upon a very different principle."

The saporimeter (Fig. 2) consists of a simple tube containing

*Translated for the *Scientific American Monthly* from *La Science et La Vie* (Paris), Jan., 1921.

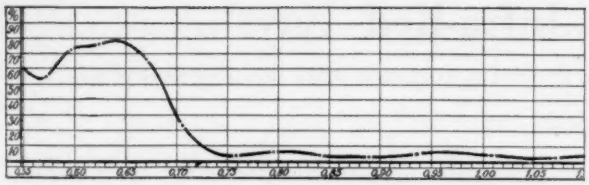


FIG. 3. EXTINCTION SPECTRUM OF CHLOROPHYLL (D-3.2 MM.), BY DONATH

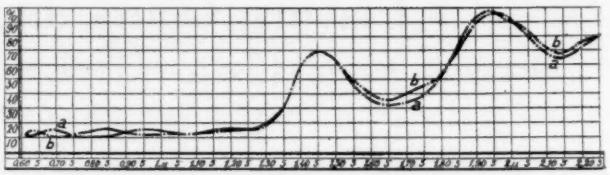


FIG. 4. ABSORPTION SPECTRA OF DISTILLED WATER (*a*) AND POTASH ALUM (*b*)

100 cm. and graduated from the top downwards. It is provided at its upper orifice with a needle valve and at the bottom with an ordinary stop cock; it is the former which is the essential part of the apparatus, since it enables the operator to control at will the access of air into orifices of capillary dimensions and consequently to retard the flow of the liquid at will. It bears a scale which enables the experimenter to reproduce at will the sections of the access of air and, consequently, the desired velocity of flow. The lower end of the tube is provided with a glass nipple which can be cleaned and which is connected by a rubber joint. Let us now suppose that this tube has been filled with wine and that the needle valve has been fitted to its orifice. The lower stopcock is now opened and a stop watch is set going at the instant when the liquid reaches the mouth of the experimenter; the interval of time required for the subject to receive the first sensation of taste, whether sour or sweet, is first noted and next the interval required before a second sensation of different quality is perceived, and finally, a third sensation which differs from the first two, after which the experiment is stopped. These intervals of time enable the operator to discover the volumes of the wine which correspond to the different sensations, while by reading the graduated tube he learns the volume which corresponds to the final sensation.

This instrument has received a practical application in those industries where taste is a factor, as in the making of wines, beers, etc.

When it is desired to make a study of any given flavor in various degrees of concentration, two tubes are used, in one of which is placed the liquid in question at any given degree of concentration, while in the other tube pure water is put; the two liquids are thoroughly mixed with each other by a mechanical apparatus. By this means it is quite easy to determine the degrees of concentration which correspond to different degrees of sensation.

M. Henry had long suspected that there is a relationship between tastes and odors, on the one hand, and the infra-red spectra, on the other, when he came across the works of Bruno Donath upon the extinction spectra of the ethereal oils (1896) and of Coblentz concerning the extinction spectra of gas and of vapors in the infra-red. The spectra given by Donath (Fig. 5) which apply to the essence of turpentine and to the oils of sassafras, juniper, rosemary, olive and petroleum between 0.7 μ and 2.7 μ are remarkably analogous. But if one takes suitable precautions to eliminate the sensation of odor, *i.e.*, by clamping the nose, one finds that all these substances have an *almost identical taste, namely, a bitter sweet taste;* taste, therefore, appears to be a function of the infra-red radiations. In the same way it has been discovered that the products of the distillation of petroleum for which Coblentz found infra-red spectra remarkably concordant have tastes and odors which are nearly identical. Potash alum, whose absorption curve differs very little from that of distilled water, according to Donath (Fig. 4) does not differ from the latter in taste, except by means of its styptic character, which is in reality a tactile sensation. Furthermore, in studying the intensity of metallic odors M. Henry found that this decreases in the same ratio as the emissive power of the metal, *i.e.*, in an opposite ratio to the electrical conductivity and to the lengths of the waves emitted; this indicates that the intensity of a metallic odor bears a relation to the intensity of minute infra-red radiations. It appears to be an indisputable fact, therefore, that taste and odor are thermic senses bearing a specific relation to wave lengths.

But it is true, moreover, that the experiments of Lefèvre with respect to the radiation homœotherms have led to the view that our own radiation is practically the same as that of a black body at 273° + 37° absolute, with a maximum λ emission of 9.48 μ. The radiations of taste and odor are of the same order of magnitude as our own radiations; the latter are absorbed or not absorbed as the case may be by bodies in contact with the papillae of taste and the olfactory fissure. It is thus clearly demonstrated that taste and odor depend upon modifications caused in our own radiation by means of infra-red spectra.

This theory at once explains a great number of facts such as the "toning" or "shading" of odors and of tastes by means of concentration or increase of temperature, since concentration causes the enlargement of the bands of absorption and causes new ones to appear, while temperature moves the rays towards the large λ; the carbides of the aromatic series are crossed by bands, while those of the fatty series are not so crossed.

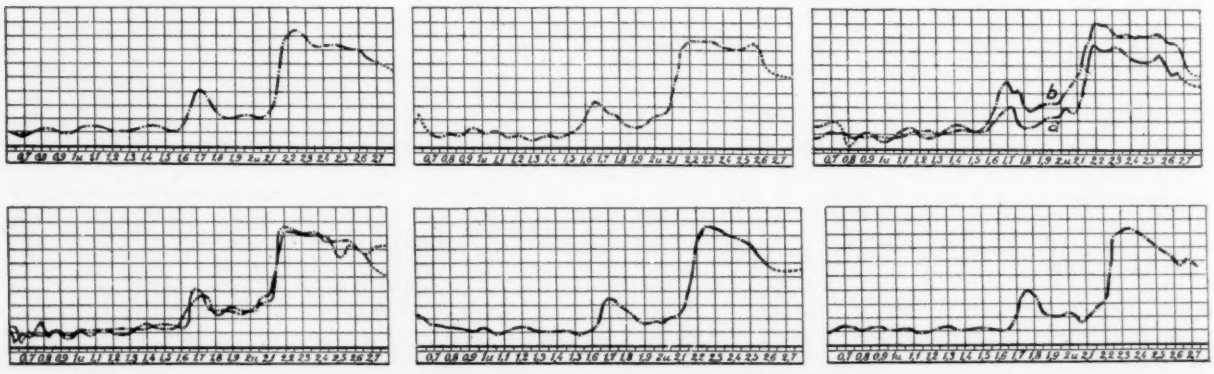


FIG. 5. OTHER EXTINCTION SPECTRA BY BRUNO DONATH

Top row, left to right: Oil of turpentine (d-0.75 mm.); oil of sassafras (d-0.75 mm.); oil of juniper (*a*, d-0.45 mm.; *b*, d-0.9 mm.). *Bottom row*: Oil of rosemary (d-0.75 mm.; *a*, Italian; *b*, French); olive oil (d-0.75 mm.); petroleum (d-0.755 mm.). Observe the striking analogy between the curves representing these spectra of substances which possess an almost identical taste when care has been taken to eliminate the sensation of odor.

The radicals common to acids or to sweet substances, the free anions of salty products, the cations of sweet and bitter substances, etc., are characteristically exhibited in the spectra. This offers another verification of the principle of the theory.

To fully establish the theory it was only necessary to take into account the principles and general facts of the physiology of sensations, to compare the known facts concerning the sensations of taste and odor with those known concerning the sensations of sound and color, and to find a connection between tastes and odors and the infra-red extinction λ. When all this had been done an effort was made to verify the theory by reproducing the tastes and odors of bodies by means of calculation.

Unfortunately, we have as yet but few data upon the infra-red spectra—it is very probable, however, and it is to be hoped that future discoveries may make it possible to find corrections in the calculated constants; especially since M. Henry has been able to obtain formulas which are undoubtedly approximately correct . . . . .

Sensations depending on vibrations.—In the case of those sensations which are caused by vibrations there are three fundamental quantities to be determined: 1. The *field, i.e.,* the

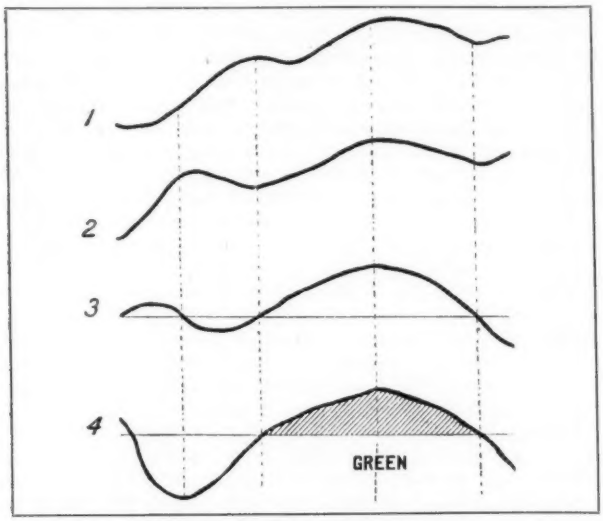


FIG. 6. CURVES OF SENSIBILITY

Curve 1 is the integral curve of curve 2 which is the curve of Uhthoff which represents the variation of $\Delta\lambda/\lambda$ in function of λ. Curve 3 is the curve of the second sensibility or the curve derived from curve 2. Curve 4 is the curve derived from curve 3 or the curve of the third sensibility.

interval within which the radiations concerned in the sensation under consideration are exerted and at the end of which the sensibility becomes once more of very slight magnitude, or a magnitude corresponding to the magnitude of the initial radiation—*i.e.*, the interval between the extreme radiations; or, perhaps, it would be better to say, for certain psycho-physical reasons, the logarithm of this interval.

2. The *period,* which makes definite a precise quality of the sensibility.

3. The *tone* or *interval* which defines a quality of the sensation.

The theory of music.—It is evident that the theory of music is merely a special application of a more general physiological theory. The theory of the representations enables us to calculate intervals of λ radiations by the expression $1 < a^{-na} < 2$**, a being equal to $\frac{3}{2}$ and n being the series of numbers from 1 to 8. These intervals differ very little from $2^{n/8}$, n representing the values from 1 to 8—these are the subdivisions of the octave.

**$a^{-na} = \frac{1}{a^{na}}$

M. Henry has applied the term *méride* to the interval $2^{\frac{1}{8}} = 1 < \left(\frac{3}{2}\right)^{\frac{1}{8}} < 2$. He designates the intervals for the successive values of n by the terms *di-, tri-, tessaro-, penta-, hexa-, hepta-,* and *octo-méride;* he designates the fractions of the *méride* ½, ⅓, ¼, by the terms *hemi-, trito-,* and *tetrato-méride.*

If we are able to arrive at a knowledge of the intervals in the case of any sensation, we can find without difficulty the periods and the fields by multiplying the value of the intervals by 6 and 6^2.

In order to find the limits of the effective field in the case of colors, we utilize the fact that the slightest visible λ radiation is in the vicinity of 393 $\mu\mu$ and that the second sensibilities of establishment are practically nil at the beginning and at the end of the field, in other words in the extreme hemi-mérides. . . . .

We thus obtain, λ and λ_0 being the extreme λ, for the log. λ_1/λ_0 the value 0.221, or a hexa-méride. In the case of colors the period is the méride in which practically each second sensibility is characteristic; the tone is 1-6 of the méride, and it is possible in practice to distinguish on the average, six tones in a méride. We have just been speaking of sensibilities of establishment; it is necessary to give the reader an idea as to the nature of these new quantities, which have a considerable degree of practical interest and which are destined to play one of the most important of rôles in future researches concerning the physiology of sensations.

Sensibility is by definition measured by the increase of the sensation or of the motor reaction connected with the increase of the stimulus: light, color, sound, etc.

Uhthoff has measured the sensibility to the change of tint in the spectrum; the sensibility to each radiation λ, before it attains its regular intensity passes through a value of establishment; it was these establishment values which Uhthoff measured. But it has been found that these values (or magnitudes) proceed at the same rate as compared with wave lengths as the instantaneous energy exhibited by the radiations of black bodies subjected to any sort of thermic disturbances whatever. This fact establishes the existence of a striking analogy between nervous radiation and electro-magnetic radiation.

Uhthoff's curve is No. 2 in Fig. 6; this is the ratio $\Delta\lambda/\lambda$ in function of the radiation λ, $\Delta\lambda$ being the smallest difference of wave lengths perceptible for a λ radiation. Curve No. 1 is the exact sum of the small areas which form the elements of curve No. 2; it represents the stationary sensations of the successive λ.

Curve No. 3 is the curve derived from the one preceding; it is the curve of the sensibility to the sensibility measured by the latter, or the *second sensibility.* Curve No. 4 is the curve derived from curve No. 3; it is the curve of the sensibility to the sensibility No. 3, or the *third sensibility.* This curve (No. 4 in Fig. 6) enables us to define mathematically for the first time the *complementaries, i.e.,* those colors whose sensations annul each other; they are the colors whose third sensibilities of establishment are of opposite signs, these sensibilities being counted starting with the small λ or with the large λ since green has no complementary color.

A SCALE OF TASTE

The varieties of tastes commonly given are bitter, salty, sweet, sour (or acid). The perceptible minima of these agree respectively to the following concentrations:

$$3 \times 10^{-6}\dagger;\ 2.5 \times 10^{-3};\ 4.9 \times 10^{-3};\ 1 \times 10^{-4}$$

From this scale the alkaline taste and the insipid taste are omitted although they may occasion quite violent physiological reactions, even causing vomiting. M. Henry finds the perceptible minima to be 4.55×10^{-4} in the case of an alkaline taste and 1.66×10^{-2} in the case of the insipid taste (dialyzed albumen). We may arrange sensations of taste in the order of

†$3 \times 10^{-6} = 3/10{,}000{,}000 = 0.000{,}000{,}3$. As we see, a number multiplied by a negative power of 10 is equal to the quotient of this number divided by a power of 10 equal to the preceding, but positive instead of negative.

their increasing radiations in the following scale, bitter, salty, sweet, and acid. But since alkalies when strongly concentrated are bitter and since the insipid taste is the complement of the salty taste, we obtain eventually, arranging them according to their increasing radiations, the following scale: bitter, alkaline, salty, sweet, acid, insipid—the last three tastes being the complements respectively of the first three.

Donath's extinction spectrum of chlorophyll (Fig. 3) enables us to calculate the period of tastes. This substance occasions a persisting sensation of bitter following a first sensation of salty. Starting with $\lambda = 0.75\ \mu$, this spectrum exhibits a series of undulations which gradually neutralize each other. All the λ of maximum energy which concur with the bitter are distants of the ratio 1.185, *i.e.*, of the di-méride; the di-méride, practically ¼ of the octave, is the period, therefore. The first maximum has place for $\lambda = 814.6\ \mu\mu$; the original λ therefore, is $814.6\ \mu\mu / 1.185 = 687.3\ \mu\mu$; this is the tonic common to tastes and to odors.

It has been found that red rays filtered through a piece of cathedral glass produce a slight sensation of bitter upon the tongue. In the case of odors M. Henry has been able to distinguish with great precision six olfactory qualities or tones which he arranges in the order of the increasing λ as follows: alliaceous (i.e. partaking of the odor of garlic or onion), turpentine, musk, ether, benzol, balsam.

There are *vaporous tastes* and *liquid odors:* thus a saline solution in the nose gives a sensation of musk. The correspondence of these sensations results from the order in which M. Henry has arranged tastes and odors. Singular and striking as experiments of this sort may appear to be, they are, as we see, very useful in establishing a rational classification of sensations and their author deserves great credit for his ingenuity.

I asked M. Henry whether any immediate practical application of these researches were to be expected. He answered me in the affirmative, replying "Yes, I have discovered means of permanently modifying both the intensity and the breadth of certain radiations. I have thus been enabled to obtain perfumes which are far superior to ordinary ones both in intensity and in delicacy."

THE FRAGRANCE OF THE EARTH

ONE of the most agreeable fragrances which salutes the dweller on the country-side is the odor of the naked earth itself. This is especially noticeable in the spring of the year when the soil has just been turned up and the fresh, moist clods are exposed to the air. But it may be noted at any time of the year when the weather is not too cold or dry being especially marked just after a rain. The odor is peculiar and has been compared to that of newly fallen leaves, of sheep's wool, of rainwater, of lime kilns, etc.; yet it is entirely individual and quite unmistakable.

In the older works on agricultural chemistry this odor was ascribed to the slow decomposition of certain chemical compounds in the ground more or less difficult to define, and then contact with the mineral elements of the ground. According to some recent experiments by Rullmann, Salzmann, Jensen and Münter published in the *Schweizerischen* Chemikeizeitung this idea is incorrect. The odor in question proceeds from certain minute fungi of the soil belonging to the group of the so-called thread bacteria, and there are two species in particular which produce a marked odor. The proof of this is found in the fact that these bacteria can be isolated from the soil and made to grow in the laboratory on the most various mediums of *organic* instead of inorganic nature, such as pea-soup, the crumbs of bread, meat broth containing sugar, milk, glycerine, starch paste, etc.

On all these the bacteria developed their characteristic odor. It was even possible to isolate to a certain extent the chemical principle of the fragrance by a special process. In this way a liquid smelling strongly of fresh earth was obtained and when this was evaporated tiny crystals were left, whose composition could not be determined.

VEGETATIVE AND REPRODUCTIVE FUNCTIONS AND METABOLISM

THE fact that plants require or absorb mineral salts in varying ratios means that such absorption and utilization depend in considerable measure upon the composition of the plant itself, and will vary as such composition is varied. Changed or changing condition or expression is the external evidence of changed or changing composition. The living plant is constantly in a state of becoming adjusted to changing surroundings; it is the product of the interaction of all the elements of its environment. A change of any one of such elements requires a readjustment of the entire system unless such a change is at once offset by another which in its effects is antagonistic to it. If this is true, the necessity of possessing some facts or knowledge concerning the composition and the transformation of compounds in the plant in connection with those absorbed from the media surrounding it, is absolutely imperative. Anyone who has attempted such analyses can realize the difficulties to be encountered without being told about them. It is not sufficient to make determinations on whole plants *en masse;* the several parts must be considered separately in as minute detail as possible and then all must be related to the whole.

This is illustrated in the case of leaves and stems, when investigating the carbohydrate situation in a series of tests. Brief reflection will render obvious the fallacies of judgment which are likely to arise, especially when samples are collected during the day following a period of sunshine. The speed of digestion of the more complex carbohydrates (if any have been synthesized) and of their translocation is widely variable depending upon the other nutrients present. The presence of equal quantities of polysaccharides, indicated by analyses of material taken at any particular moment, in itself could by no means be interpreted as indicating an equivalent rate of synthesis, utilization, or storage of such products. These latter points could be determined only by a long series of analyses under varying conditions, or through indirect methods quantitatively measuring respiration, carbon fixation, and the like. Caution must be observed, also, in attempting interpretations of the analyses of plants already in any particular state or condition, the cause of which it might be desired to determine; it is only through the knowledge of a series of effects that causes can be deduced. For example, an analysis of fruit buds of any kind of fruit tree made during the winter or early spring will not furnish sufficient evidence on which to formulate a theory as to the nutrient relations necessary for their differentiation or presence. Instead, a number of observations from spring to winter are essential, for it is more than probable that the conditions determining meristematic differentiation are quite different from those accompanying the further development of the parts in question after initial differentiation, and the conditions for flowering may not be those for fruit setting and development.

The question may be asked, how is any knowledge of the relationship of vegetation and reproduction significant to practice? In reply it may be stated that it is at the very foundation of the whole matter of plant production, for on it rests the real understanding of such problems as cultivation, fertilization, irrigation, propagation, pruning (regeneration), phases of disease control, and many others. Certain points of attack become obvious at once to anyone really giving the problem thought. Even the working horticulturist is constantly contributing excellent experimental evidence, and is eager for some rational means by which he can interpret it.

In conclusion, then, it seems that the most needed essential to further extension of knowledge on the effects of varying metabolic conditions on the modification of vegetative and reproductive functions is the coordination of our knowledge of external and internal conditions. The working out and making available for study of the range effects of many more elements and compounds than the very few which are known at present is particularly desirable.—Abstract from article by Dr. E. J. Kraus in the *American Journal of Botany* for December, 1920.

Light and Chemical Energy*

Perrin's Brilliant New Theory with Regard to Effect of Wave Length Upon Reactions

By Professor Pierre Weiss, of the University of Strasbourg

In this address Professor Weiss has set forth lucidly and interestingly the main features of the very important and novel theory recently propounded by the distinguished physicist, Jean Perrin, to the effect that chemical energy is a direct result of the wave length of the various rays found in the visible and invisible spectrum. We omit the opening paragraphs of the address since they deal with such well-known properties of light as reflection, refraction, diffusion, etc., with which our readers are undoubtedly already familiar.—EDITOR.

LET us now consider the question of polarized light. As we know luminous vibrations are transverse instead of being longitudinal like those of sound. A metaphor will readily enable us to understand what is meant by the polarization of light. It is a simple matter to put a letter in the mail box if we present its edge parallel to the slit in the box, but if we present it in a perpendicular position to the slit it will not enter. The apparatus known as a polarizer may be compared to a letter box having a vertical slit. Let us now suppose a second slit in the letter box opposite the first. If these two slits are perpendicular to each other the letter will not pass through; if they are parallel it will pass. Correspondingly we may take a second polarizer and place it opposite the first in the path of a ray of light. To distinguish the two we call this second polarizer the analyzer, a word which expresses its function. The first apparatus is placed so as to allow vertical vibrations to pass. If the analyzer is arranged in the same way light will pass through the two without any difficulty, just as the letter passes through the two parallel slits in the box. But if we cause the second apparatus to revolve 90° around the ray of light as an axis of rotation, in this position it will allow only horizontal light to pass, and since the light coming from the polarizer is vertical no light will be able to pass.

Now let us make an experiment. By the rotation of the analyzer at a right angle we pass from full light to darkness, *i.e., extinction* and then by a new rotation, likewise of 90°, we pass from extinction to full light and so forth. It is obvious that this experiment can be comprehended only by supposing that light has a transverse vibration, since if light were moving in the same direction as the ray there would be no change.

Let us now interpose between the polarizer and the analyzer in the extinction position a sheet of a crystallized substance, e.g., a sheet of gypsum having an unequal thickness between one end and the other and obtained by the cleavage of a crystal of gypsum. Crystallized matter possesses the property of causing a profound disturbance in the direction of the vibrations of light which it receives. The vertical vibration falling upon it will be rendered partly horizontal, thus allowing light to pass. But since this effect is unequal in extent in the case of light rays of different colors, very vivid colors will frequently make their appearance. Thus we shall see certain areas of the gypsum appear upon the screen as red, others as green, and still others as yellow. Each thickness of the gypsum will give a different mixture of colors.

Now if we turn the analyzer at a right angle the light which passed in the previous experiment will be arrested and vice versa . . . so that in the second part of the experiment we shall obtain the colors which are the exact complement of those in the first, since the ensemble produced white light.

Instead of observing these two aspects of the light successively we can obtain them simultaneously side by side upon the screen, in which case we see clearly that a green area in one corresponds to a red area in the other and so on.

I have here several objects made from another crystalline substance — mica — such as the petals of a flower and the wings of a butterfly. These are formed of sheets of mica of different thicknesses; when we place them between the polarizer and analyzer we see the image of the butterfly or of the flower appear in colors upon the screen, and when we throw them upon the screen side by side at the same time we shall have a butterfly and a flower tinted in complementary colors.

The phenomena due to the transverse nature of vibrations and the possibility of separating these into different directions around the ray of light are very various in nature. Instead of obtaining the re-appearance of the light by placing between the polarizer and the analyzer a sheet of crystalline substance, we may arrive at an analogous result by using a parallelepiped of ordinary glass. We can accomplish this by imparting to the glass artificially optical properties which vary with the direction. This is done by exerting strong pressure upon the glass in which case the compressed glass acts like a crystal and the direction of the pressure exerted corresponds to one of the axes of this crystal. And we find that the stronger the pressure exerted upon the glass the more intense the light which reappears. And by studying this phenomenon mathematically we can even deduce the exact distribution of the internal tensions of which the substance is the seat. And it has been found possible to find an optical solution of delicate problems with respect to the resistance exhibited by various materials, by reproducing in glass pieces of metallic framework which are difficult to calculate, and then exerting upon the glass tensions or stresses identical with those to which the pieces of metal are subjected.[1]

These tensions are also encountered in tempered glasses, i.e., glasses which have been heated to a red glow and then cooled with sufficient abruptness to cause the surface to regain its rigidity first. We shall examine between the crossed analyzer and polarizer a series of such specimens of glass and we shall see that the very vivid play of colors observed gives a faithful image of the state of internal tension of the different areas.

Finally, we know that quartz crystals share with certain compounds of organic chemistry a certain property which has provided chemists with a key to the asymmetries of the molecule, namely; the power of rotation. But in the quartz this rotatory power which is manifested in full perfection only in the direction of the axis of the crystal, is a result of the crystalline structure. In the crystal of quartz the successive vibrations of the light are arranged like the steps of a winding staircase. If we interpose a plate cut from a crystal of quartz between the polarizer and the analyzer in the extinction position the rotation which it imparts to the vibrations will have the effect of producing a luminous movement which the analyzer will allow to pass. And since the rotation is unequal for the different parts of the spectrum the reestablished light will exhibit colors. Indeed, the colors due to the power of rotation are among the richest which we know how to produce. The artifice which we have already employed will give us a color and its complement at one and the same time and since it is

*Translated for the *Scientific American Monthly* from an address made June 2, 1920, at the Congress of the Union of the Industrial Societies of France, and published in the Bulletin de la Société Industrielle, Mulhouse (France), for June-July-August, 1920.

[1]See "Determining Stresses by Polarized Light" by George Weed Hall and Arthur L. Kimball, Jr., in *Scientific American Monthly*, January, 1921, pp. 49-53.—EDITOR.

easy to superpose the two images we shall again see white light reconstituted by each couple of colored areas—blue and orange yellow, red and green, salmon and greenish blue.

If we observe the waves which traverse the surface of a sheet of water we perceive at once that there is a definite distance maintained between each two consecutive waves; this represents the length of the wave. With our crossed analyzer and polarizer we can perform one of the many experiments which enable us to determine the wave length of light. In the the rectangle of red light thrown upon the screen you observe a series of parallel bands which are alternately light and dark. We have divided the luminous movement into two portions. In the luminous band farthest to the right the two luminous movements arrive at the same time and reinforce each other. In the adjacent dark band one is half a wave-length behind the other, in consequence of which they counteract and destroy each other; a little farther in the second luminous band the retardation is twice as great, which gives us an entire wave and the movements once more added together, producing the full strength of light, then in the following band there is a retardation of 1½ wave lengths so that again the crest and trough of the waves meet and neutralize each other, and so on. . . By calculations based upon this phenomenon the wave length of the red light at the far end of the spectrum has been found to be eight ten thousandths of a millimeter.

Let us repeat this experiment performing it at the same time with red light and with green light, which we obtain by filtering white light through colored screens. Now let us place the two phenomena side by side—we observe that the red bands are farther apart than the green ones and perceive that the wave length of green light is shorter than that of red light. At the most highly refractive end of the spectrum the wave length is only four ten-thousandths of a millimeter. In the ultra-violet the length is still shorter while it is considerably longer in infra-red. The longest wave lengths of light which have been measured are one and one half tenths of a millimeter.

Let us suppose now that the temperature of a body is gradually raised. At a point slightly above 400°C. the rays emitted will begin to make an impression upon the retina of our eye and the body will appear dark red, passing later through cherry red and orange until it reaches an increasingly dazzling white . . . The proportion of the various rays alters and the higher the temperature becomes the richer the light is, both absolutely and relatively in violet and ultra-violet rays. If we reverse the experiment by cooling the body we gradually reach the red light and, finally, this becomes too feeble to impress the retina—beyond this point we have the infra-red rays whose wave length is the longest known.

Now let us imagine a closed metal box in which a vacuum has been produced and which is then heated from the outside. The internal walls will become incandescent as the temperature increases and will emit light which will traverse the box at the prodigious velocity at which light travels, i.e., 300,000 km. per second, until the light from one wall reaches the opposite wall where it will be reflected or absorbed. We perceive, therefore, that it is not precisely correct to say that this box contains *nothing;* as a matter of fact it contains radiations moving in every direction. And these radiations consist of a mixture of lights of all the colors and of all the wave lengths in proportions depending upon the temperature of the box at any given moment. If the temperature is lower than 500°C. there will be practically no visible rays present, but only infra-red rays.

Now the same process of reasoning holds true if we imagine the box instead of containing a vacuum to contain a solid liquid or gaseous transparent medium and if we cool it to the ordinary temperature of the air which surrounds us. In other words this very room in which we are assembled represents such a box. It is evident, therefore, that we are as a matter of fact, immersed in infra-red rays which come from every direction to strike and penetrate our bodies. All the work which we do, every operation we perform in our daily lives takes place in a bath of infra-red rays. When we consider this evident fact it seems curious enough that no one has ever thought of assigning to this agent a rôle of importance in the phenomena which surround us.

THE CHEMICAL ASPECT OF THIS PHENOMENA

Let us now examine the problem from a chemical point of view. Anyone familiar with chemical laboratories knows the important part played by heat in chemical processes. Whether he is concerned with one of the thousand operations of qualitative or quantitative analysis, whether he is dissolving a metal in an acid obtaining a precipitate or observing a color, the chemist nearly always heats the test tube in which the reaction takes place. A whole series of operations is conducted, by heating the bodies subjected to the experiment by means of a gas burner while they are traversing a tube.

Early chemists made much use of furnaces fed by wood charcoal; now-a-days, we have coke furnaces or electric furnaces . . . such as those, for example, with which Moissan made his brilliant discoveries . . . It is a well-known fact that a rise of temperature accelerates chemical reactions, whereas a fall of temperature retards them. At the temperature of liquid air reactions which are violent at ordinary temperatures—such, for example, as that of sulphuric acid upon potassium—are benumbed. But it is an accepted fact that heat is due to molecular motion and that chemical combinations and decompositions result from the violent shocks produced between molecules which come in contact with each other because of this motion. But there are some difficulites in the way of accepting this theory.

When there is a rise of temperature to 10°C. above the ordinary, the kinetic force of thermic agitation is augmented by a thirtieth and the velocity of the molecules by a fifteenth of their value. But there are a great many chemical reactions whose velocity increases much more rapidly—when it is even doubled, for example by a rise of ten degrees. It seems strange that there should be such a disproportion between cause and effect.

There is another difficulty which is perhaps even more serious. Let us suppose the case of a small quantity of the vapor of hydriodic acid (HI) in a closed container, say a liter. Let us now raise the temperature to such a point as to cause the vapor to break up into its component elements, hydrogen and iodine. This dissociation will take place at a certain rate of velocity.

Let us now put the same amount of vapor at the same temperature in a container holding 1000 liters. The molecules moving at the same velocity will have a thousand times as much space at their disposal and shocks of contact between them will be only 1/1000 as frequent. And yet we know by experience that the dissociation takes place with the same velocity. Therefore, it would seem impossible that the dissociation is produced by the shocks of contact between molecules due to thermic agitation.

But these difficulties and discrepancies vanish if we assume that the reactions are occasioned, not by the thermic agitation itself, but by the accompanying radiation. Thus no matter what the size of the container at the same temperature the molecules of hydriodic acid would be immersed in the same medium, consisting of infra-red radiations—and, if the temperature is high enough, of visible and ultra-violet radiations also—rushing through space in every direction. If we could accept this theory therefore there is nothing to surprise us in the fact that the velocity of dissociation is independent of the space occupied by the substance.

RELATION BETWEEN LENGTH OF WAVE AND CHEMICAL ACTION

We must believe with Perrin that every chemical reaction is produced by a radiation having a specific wave-length. If this be true it would suffice, in order to estimate the variation in velocity of the reaction due to temperature, to know the vari-

ation in the amount of this *active light* within the complex mixture of radiation. But it is a very remarkable fact that this calculation leads us to precisely that law which Arrhenius deduced from experiment some 30 years ago and which has hitherto remained inexplicable.

Inversely if we determine by experiment the velocity of the variation in a reaction due to temperature we can determine the wave-length of the ray of light which causes the reaction. For this purpose it is only necessary to choose among the complex mixture of rays of light of different wave-lengths that which has the same velocity of variation. Much study along this line will doubtless presently be undertaken—we will merely say now that in those cases in which such a calculation has thus far been made the wave-lengths obtained have been entirely plausible.

Let us now examine the same question from a different point of view. We know that colored substances merely select certain rays from white light and reflect them, while they absorb and destroy all the others. But there is one very important exception to this rule. Let us take a substance termed fluorescent, *e.g.*, a piece of glass containing certain amounts of salts of uranium incorporated with it. Expose this to a beam of light containing only the violet light which we obtain by passing a beam of white light through a colored filter. In this violet beam the uranium glass will shine brilliantly diffusing in every direction a vivid greenish yellow light. Thus we see that uranium glass is capable of transforming the original violet light into yellow light, *i.e.*, a light different both in color and in wave-length.

Organic chemistry provides numerous examples of fluorescent substances among which some of the best known are fluorescein, eosein, esculin, quinine sulphate, etc. The phenomenon is often intense enough to be perceptible even when the fluorescent substance is present only in an exceedingly dilute form or in extremely thin sheets. M. Ferrin placed under a microscope an extremely thin layer of a solution of these substances and exposed it to an exceptionally strong light by projecting upon it the image of the electric arc light. He was thus enabled to make an important and fruitful observation, namely: that the fluorescence of that part of the substance touched by the image of the arc light is extinguished at the end of a few minutes. If the preparation is so placed as to expose fresh portions of the substance to the light, these portions will become fluorescent and then be extinguished in their turn. It is evident, therefore, that fluorescence is not, as had been thought, a permanent quality of certain molecules, but is, on the contrary, the visible sign of their disappearance. The molecule struck by a certain radiation, by violet light, for example, dies as it projects a flash of green light and gives birth to a molecule of a different kind. The reason why the destruction of the substance at the moment it becomes fluorescent had hitherto been unperceived, is that until Perrin made his experiment investigators had always made use of too feeble an illumination and had employed such large quantities of the substance that the diminution of the latter could not be observed.

M. Perrin looks upon fluorescence as the typical case of all chemical reaction: a radiation is absorbed and occasions the reaction which gives rise to the emission of another radiation. The peculiarity of fluorescent substances consists in the fact that the radiation emitted and in many cases also the radiation absorbed are found in the visible spectrum. But when we remember that the invisible spectrum is far more extensive than the visible spectrum including both the infra red and the ultra-violet rays, there is nothing surprising in the idea that the eye fails to perceive any radiation in those reactions which are the most numerous and most ordinary of all. M. Perrin has gone a step further deducing by the doctrine of quanta (which there is no need of going into here) from a knowledge of the wave-lengths of the exciting light and the emitted light the amount of heat liberated in a given chemical reaction. The calculation made by him concerns the transformation of ozone into oxygen and the figures obtained were 62,099 calories, whereas 60,000 calories are obtained by direct observation. This is, very evidently, remarkably close agreement.

Let us take another experiment:

Let us expose to daylight some calcium sulphide containing traces of metallic impurities, and afterward examine this substance in a dark room. At first it shines with a comparatively bright light, but the intensity of the light diminishes by degrees. This is the phenomenon known as phosphorescence. The substance has absorbed certain rays of the light to which it has been exposed and later it yields these up. While this phenomenon is somewhat akin to fluorescence, it is distinguished from it by the fact that in reality it comprises two inverse reactions.

When the substance is exposed to sunlight some rays present in the incident light causes a chemical reaction of unknown nature and this reaction is accompanied by the emission of a certain infra-red ray. An exactly inverse reaction is involved necessarily in the re-emission of the absorbed light and the absorption of the emitted light. But in the mixture of infra-red rays in which all substances are immersed at ordinary temperatures, the substance will find the precise radiation which it emitted to begin with. This radiation will incite the inverse reaction and as a result, the incident light will be emitted.

This theory suggests a method of verification. If it be true that it is a certain infra-red ray which causes the emission of the stored up light, then it ought to be possible to increase the effect by increasing the intensity of this infra-red light. This can be done by exposing the phosphorescent substance to the infra-red spectrum of an incandescent body. As a matter of fact this experiment was actually made by E. Becquerel a good many years ago, but the results remained unexplained until it was found that they accord with Perrin's theory. When such exposure is made we first observe a more intense emission at those points where certain infra-red rays of a suitable wave-length fall upon the substance, but in these same areas the phosphorescence is more quickly extinguished so that they quickly become black, in contrast to those parts of the preparation which have not been exposed to the infra red ray.

Another manner of augmenting the intensity of the infra-red consists in raising the temperature. Behind a stream of calcium sulphide which has been previously exposed to sunlight we placed a rectangular plate of sheet iron heated to about 100° C. That area of the screen opposite the sheet iron becomes far brighter than the neighboring areas. But after a very short time their stored up light is exhausted and they become black.

The development of M. Perrin's theory promises to be of great value in science. If these new ideas are correct and it must be admitted that these primary verifications recited by us constitute a strong presumption in their favor, it is impossible to doubt that the knowledge thus gained of the actual mechanism concerned in chemical reaction must have a profound influence upon the development of both pure and applied chemical science.

We can readily imagine, indeed, a state of development of our chemical knowledge in some future day when, instead of making a crude use of the entire spectrum of radiations yielded by a given temperature, in which case certain ones of these rays produce the desired reaction, while others, on the contrary, produce the opposite reaction so as to partially cancel the effect, while still others produce what may be termed parasitic reactions—instead of this clumsy method let me repeat, we shall know how to make a definite choice of the precise ray required to produce the given effect. And let us make a solemn vow that in the future French science shall no longer be content merely with originating new theories and methods but shall determine to reap her fitting share of the harvest whose seeds she has sown.

Developing without a Dark-Room*

Phenosafranine as a Desensitizer of Ordinary, Orthocromatic and Panchromatic Plates

By Raymond E. Crowther

IN 1898 Mercier was granted a patent for a process of correcting over-exposure effects. The process comprised a bathing of the plate in dilute solutions of various substances, including several of the well-known developers, with subsequent drying.

This patent attracted the attention of Lüppo-Cramer, who made tests under varying conditions of the substances referred to, and in 1901 published his conclusion that the major effect of the patented process arose from desensitization of the emulsion by the solutions employed. He found that the specified substances desensitized to different degrees, but that generally with developers of the para-amino-phenol class the destruction of the original sensitiveness was of such an order that a plate bathed in a normally constituted developing solution could be exposed with impunity to a light which would fog a similar plate not bathed in developer.

Interest in the desensitization aspect of the matter was revived in 1907, when Lumière and Seyewetz confirmed Lüppo-Cramer's results, and made the observation that mere wetting of a plate with water considerably reduced its sensitiveness. Lüppo-Cramer immediately returned to the subject, and found that whereas only a very slight diminution of sensitiveness resulted from the wetting of a plate, the desensitization caused by immersion in certain developing solutions was quite marked with many types of emulsion, and, further, that the addition of sulphite to the developer powerfully inhibited the reduction in sensitiveness.

Continuing his work, and varying the developers and the methods of compounding their solutions, it was found that the greatest depression of sensitiveness was caused by dilute plain water solutions of amidol, triamino phenol, triamino benzol and triamino toluol in the form of their commercial salts —the hydrochlorides. Using a 0.05 per cent. solution of these compounds, for example, it was established that the sensitiveness fell, on bathing a plate for one minute, to one two-hundredth of its original value in the case of amidol, and as low as one six-hundredth of its original value in the case of triamino toluol hydrochloride. This led at once to a practical method of developing ultra-rapid non-color-sensitive plates in bright yellow light, all that was necessary being a preliminary bathing in the dark for one minute in a 1:2,000 solution of, say, triamino toluol hydro-chloride. Thereafter the plate may be lifted from the solution in bright yellow light and developed by inspection in a light sufficiently powerful to fog wet slow bromide paper rapidly.

But in these days of the more or less common employment of ortho', screened ortho', and panchromatic plates the matter could not be allowed to rest at this stage of incompleteness, and it became necessary to find a substance which would desensitize these varieties of plates and render their development by inspection a feasible proposition.

The happy spirit of co-operation which is the mark of scientific workers in every country placed at Lüppo-Cramer's disposal the range of products manufactured by the German dye-making firms, and knowing what type of substance was likely to be of service by reason of its chemical constitution, it was not long before the problem was solved. The final choice was made of the dye known as phenosafranine, and the effectiveness of this body is such that for the development of non-color sensitive plates in a yellow light bright enough to allow of the comfortable reading of newsprint at two yards' distance from the light, it is only necessary to replace one-tenth of the water used in making up one's favorite developer with an equal volume of a 1:2,000 solution of the dye, and screen the plate from the light during the first half minute or so in the developer. An easier method, and one which is applicable with complete success to panchromatic plates, is the following:

In the dark the plate is immersed in a 0.05 per cent. solution of the dye, and any time after one minute's immersion it may be removed therefrom in bright yellow light—or even by the light of a candle or oil lamp at a distance of 5 to 6 feet and developed by inspection. The plate may be lifted from the developing solution and inspected by transmitted light with impunity, a circumstance which indicates that the action of the dye is not simply that of a screen serving to cut off harmful light. As a matter of fact, one minute's immersion of a dry fixed out plate in the 0.05 per cent. solution of the dye stains the gelatine a bluish shade of red which, when examined by the spectroscope, is found to transmit the whole visible spectrum, only partially absorbing a short section at the junction of the blue and green. The worker who develops continuously will place his plates in the dye solution contained in a tank and remove them as he is ready for developing them, being unconcerned whether he is dealing with an ordinary, ortho', or panchromatic emulsion.

It may be objected that the dark-room is not entirely abolished and that the process offers no advantages over the method of bathing the plate in the dark before development with a dilute solution of potassium iodide, as recently recommended by F. F. Renwick, but a moment's consideration will convince one that the new process marks a real advance, for the immersion of the plate in the dye solution necessitates only a dark cupboard or recess, and can be undertaken by the least skilled hand in the workroom.

As far as comparison with the potassium iodide process is concerned, it is only necessary to recall that, in addition to the disturbance of the density obtainable, it is necessary to remove the potassium iodide by washing in the dark, to use special developing solutions, and a potassium cyanide fixing bath, and contrast these conditions with those of the pheno-safranine process, to rate the latter at its true value. In the new process there is no disturbance of the plate's characteristics; no washing after the one-minute immersion in the dye solution is called for; any developer may be used according to the particular fancy of the operator or the demands of the subject, and the usual hypo bath suffices for fixing. Further, the phenosafranine treatment considerably reduces the amount of chemical fog frequently encountered on pan-chromatic plates.

In one respect it is unfortunate that the most powerful desensitizer so far discovered happens to be a dye which, by virtue of its chemical constitution, tenaciously stains the gelatine. Somewhat prolonged washing in running water is necessary for its complete removal. This is not an uncompensated drawback, however, for one can be certain that when the film is washed free from dye it is also free from hypo. In cases where prolonged washing with water is inconvenient there are two methods available for hastening the operation. The first is to treat the developed, fixed and approximately hypo-free plate with a bath made by mixing equal volumes of a 2 per cent. alum solution and a 5 per cent. hydrochloric acid solution. The latter solution can be readily prepared by diluting one volume of the commercial acid with six volumes of water. The action of this bath depends upon the decomposition of the gelatine-dye complex by the acid, the strength of which is sufficient to act adversely on the gelatine unless the latter is protected—hence the use of the alum. Two or three two-minute changes of this bath allows of the removal of the dye by short subsequent washing. The second

*Abstracted from the *British Journal of Photography* March 14, 1921.

method of shortening the wash is the treatment of the hypo-free plate with a dilute solution of nitrous acid, whereby the dye is converted into a bluish violet compound which possesses but little affinity for the gelatine. The nitrous acid solution is conveniently prepared by dissolving five grains of sodium nitrite in two ounces of water and adding thereto ten minims of commercial hydrochloric acid. A four- or five-minutes' treatment with this bath should allow of a colorless film being obtained after five minutes' subsequent washing. In the writer's experience, the removal of the dye by simple water washing is preferable to either of the "short-cut" methods, and of these latter he prefers the acid alum treatment.

The dye with which Lüppo-Cramer carried out his research was the chemically pure product, and the writer has confirmed all his conclusions when using a sample of the same substance. This product in its pure form is not, however, an article of commerce, but the writer believes that a well-known firm of plate makers is about to place on the market a dye which exhibits all the desirable characteristics of pure phenosafranine.

Experimental Phonetics

Modern Methods of Studying the Production, Perception and Analysis of Sounds

By May Tevis

IN the widest sense of the word the science of phonetics embraces the whole domain of sound, including both noises and musical notes as well as articulate speech. In this wide sense it also involves a study of all the instruments, whether artificial or natural by which sound is produced and since sound can be perceived by us only through the medium of the ear, the past master of phonetics must understand the physiology of the auditory apparatus.

Such a past master in every branch of phonetics is the distinguished French savant, the Abbé Jean Rousselot. For this distinguished priest, who is now in his 75th year, a special Chair of Experimental Phonetics, has just been created under the auspices of the Bureau of Public Instruction, at the College de France, where he has been in charge of the laboratory of phonetics for something more than 20 years. Beginning with a small equipment and limited funds, M. Rousselot has, nevertheless, through his skill, ingenuity, and enthusiasm, succeeded in making his laboratory a marvel of completeness, so that no less than 18 others, the best equipped of which is that at Hamburg, have been modeled upon it. Much of the apparatus employed by him has been actually made by him and his pupils. The science of phonetics owes much to him, not only because of his inexhaustible passion for research, but because of his original inventions and of the improvements made by him in the apparatus devised by earlier students. Before describing some of this apparatus, let us cast a glance at the history of his life. Born in humble circumstances and apprenticed to a nail maker, he displayed so much talent for languages as to attract the attention of his teachers when hardly more than 13 years old. But it soon became evident that spoken language held far greater fascination for him than written words, and step by step he enlarged his field of research until it embraced the vast domains suggested above.

He soon found, for example, that he could not fully understand the most interesting and important branch of phonetics, that of human speech, without understanding the anatomy of all those various organs, a list of the more important of which we give elsewhere, which are concerned in human utterance. This, of course, opened up to him the further realm of acoustics, and through his studies of speech and hearing and through the instruments he devised for measuring and recording the changes in the lips, tongue, larynx, nostrils, etc., he has done much to assist the deaf to learn, to speak, and to read the speech of others by a study of the lips.

Finally, the most recent realm in which his knowledge and skill have been made to serve his fellow men is that dealing with the relation between sound and ballistics. During the war he spent many months at the front, erecting his delicate apparatus in the Forest of Fontainebleau. Here he and his assistants performed with marvellous accuracy the vital task of locating the batteries of the enemy. This was done by the analysis of the confused uproar of the battlefield into its component sounds, and recording the characteristics of these, so that with the aid of tables and charts it was possible to determine their origin and the distance of the source.

The term "vocal organ" includes all the organs used in speaking and singing. In order the better to understand the apparatus by which they and the sounds they make, can be studied in the laboratory it is best to remind the reader what these are:

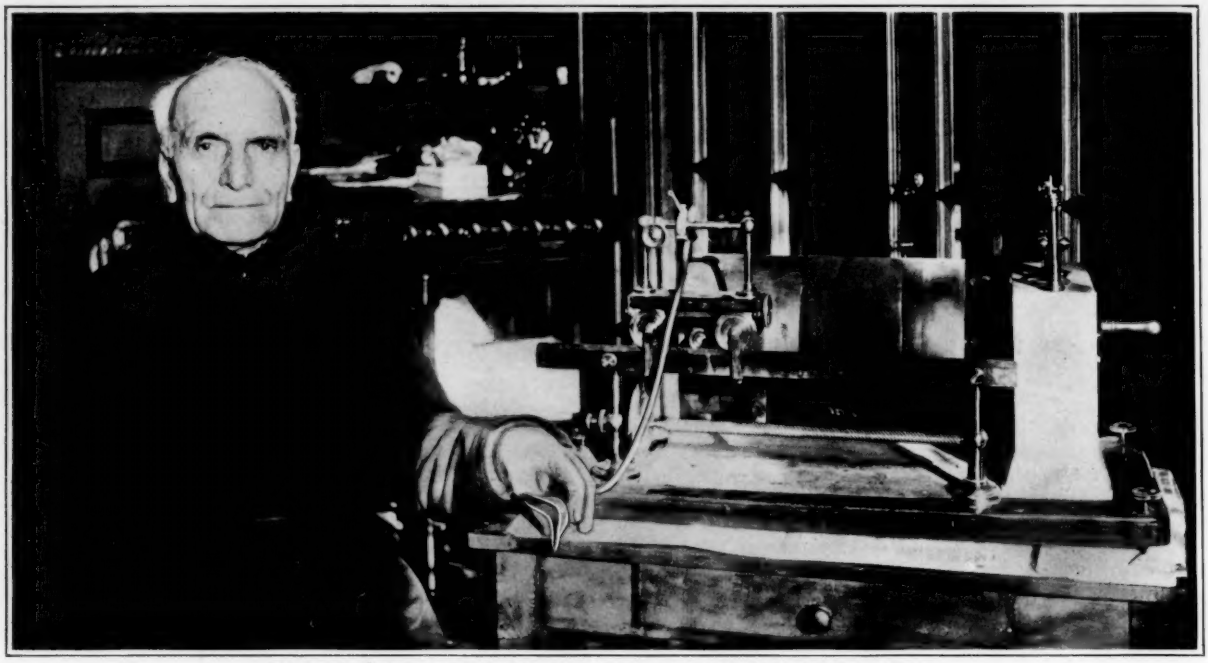
The *trachea* is the outlet for the lungs. The rings of cartilage keep it distended. Behind it lies the oesophagus and the backbone. The trachea ends in the *larynx* which contains the vocal cords. In ordinary respiration the air passes through the trachea and larynx past the *epiglottis* into the *pharynx* through the *nasal cavity* and out the *nostril* on each side.

The *nasal cavity* on each side is of very complicated form owing to the various processes projecting into it. The *oral cavity* is roofed by the *hard palate* and the *velum* or soft palate. The *pharyngeal cavity* may be divided by closure of the velum across it into two parts, the upper or nasal portion and the lower or oral portion. In this case the entire mouth cavity from the lips to larynx is made up of the oral portion and the pharyngeal portion. The fall of the velum turns the pharynx into a single cavity and separates it more or less from the oral cavity.

The muscles controlling the movement of the lower jaw are: 1. the *temporal*, which raises it, and, if it has been projected, draws it back; 2, the *masseter* which raises it; 3, the *internal pterygoidal*, which raises it and may give it slight side movement; 4, the *external pterygoidal*, which projects it or twists it to one side. The last two muscles are attached to the back part of the jaw.

The *orbicularis oris* consists of a muscle layer formed of fibers radiating from the corners of the mouth into the upper and lower lips, some of the fibers running around the corners. When the fibers of the upper and lower lips act together, they constrict the mouth. Physiologically each of these muscles is considered to be divided into an outer zone and an inner zone. When the outer zone alone is contracted the lips are compressed and thrust forward, while when the inner zone alone is contracted the lips are pressed back against the teeth. Moreover, each lateral half of each muscle is able to act independently. We cannot here describe all the various muscles which are brought into operation. Enough has been said to show the great complexity and delicacy of the apparatus which has been developed by man in the course of untold ages, not only for the production of sound, but for its modification in literally thousands of ways to form the words and cries by which he expresses his emotions and thoughts and holds intercourse with his fellow creatures in a multitude of languages.

Some of the apparatus invented or perfected by the Abbé Rousselot has had for its special object the recording, with minute precision, of the infinite variety of motion in the lips, the tongue, the nostrils, and other organs, by means of which vowels, consonants, musical notes, and words are formed and modified. As an example of the minute attention devoted by Rousselot to every phase of the subject we may mention the fact that after two months of careful phonetic observation, he perceived for the first time the differences between the speech of his



M. L'ABBÉ ROUSSELOT AND HIS APPARATUS FOR RECORDING SPEED

mother and that of himself, and noted that a regular progression in change of dialect could be observed in the speech of three generations of the same family; he also found that there were stages of phonetic change even from village to village, which throws an interesting light upon the development of dialect.

He has in fact, made an extremely comprehensive study of French dialects, and particularly of that of Paris, to which he has devoted a special volume.

THE PHONETICS IN SPEECH

Sounds differ from each other in three factors, pitch, intensity or loudness, and quality. The most important of these, so far as speech is concerned is the quality. In articulate speech sounds are divided into two broad classes—vowel sounds, which can be held for a considerable length of time, and consonantal sounds, which consist essentially of a peculiar stopping or starting of a vowel sound, and which often are employed in forming a transition from one vowel sound to another.

It is a curious fact that just as the intensity of a sound decreases with the distance of the hearer from its point of origin, so does the barely perceptible difference in speech sounds change at different distances. Studies by Wolf of various sounds in the German tongue show the vowel *a* is capable of being heard at the greatest distance, and this distance decreases gradually in the following order, *o*, *ai*, *e*, *i*, *au*, *u*, *sh*, *m*, *n*, *s*, *f*, *k*, *t*, *r*, *b*, *h*. In some similar experiments Rousselot found that no sound was distinct when spoken in the usual tone of voice at a distance of 9.6 meters, but that when this distance was diminished to 9 meters the ear understood *a*, *e*, *i*, *o*, and *y*, *p*, *k*, *t*, at 8.55 meters; *b*, *sh*, sometimes *s*, rarely *f* at 7.10 m.; *s* and *f* very distinctly *at* 7 m.; *d*, *m*, *n*, at 6 m.; *zh*, *g*, at 5.7 m.; *zh*, at 5.5 m.; *v*. *u*, *œ* at 5 m.

Professor E. W. Scripture, one of our leading authorities in America upon phonetics, terms this property of speech sounds *acoustic penetration* and he suggests that analogous experiments to these of Wolf and Rousselot might enable us to make a systematic investigation of the penetrative power of the various sounds in any given language in a given speaker or singer of given conditions of mind or body and of given methods of speaking.

Rousselot's Vocal Tambour.—One of Rousselot's inventions is known as a vocal tambour. It consists of a bent metal tube one end of which is covered with a rubber membrane, which moves a very light stylus. A mouthpiece is fitted into the other end of the tube and the vibrations of the membrane produced by the sounds of the voice in front of the mouthpiece are recorded by a lever which is made adjustable by a screw. This tambour is admirably adapted to recording small variations of pressure, such as are found in various speech sounds like *r*, the explosives, etc.

The methods used for studying muscular movement include, among others, that of air transmission by Marey tambours.

The tambour is a metallic box with a rubber top and a side tube.

Artificial Palates.—The contact of the tongue with the palate is studied by a thin shell-like artificial palate which is covered with chalk and then placed in the mouth. The impressions made upon it by the tongue are known as palatograms. Rousselot has published plates showing dozens of these. It seems probable, however, that even the thinnest plate somewhat modifies the record.

The Phonograph.—Though of great service in the study of speech sounds the phonograph is too well known to be described here.

TUNING FORKS

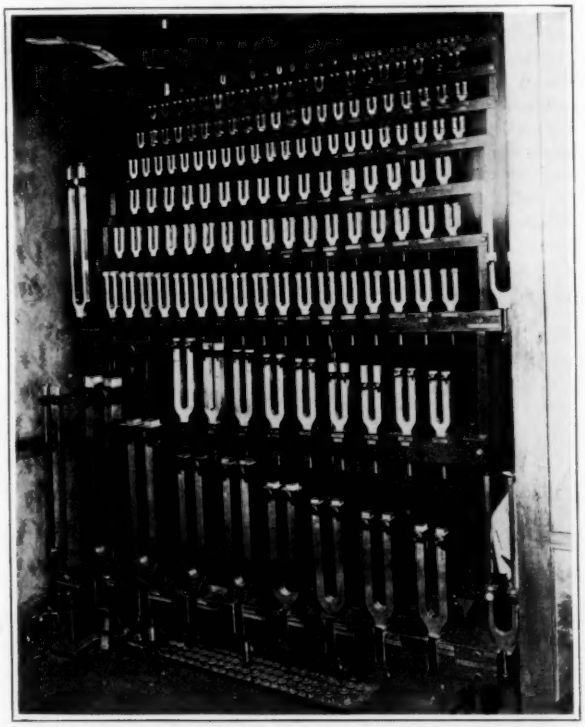
One of the simplest instruments for determining pitch is the tuning fork. This instrument consists of a resonant bar of metal bent into the shape of the letter U, and provided with a handle at the bottom of the U. When struck it vibrates so as to produce a musical note and this note varies in pitch according to the size and the weight of the fork. Tuning forks like other vibrant bodies have the quality of resonance. When a vibrating tuning fork producing a note of a certain pitch is brought near a collection of other tuning forks of different sizes and consequently of carying pitch, those which are attuned to the pitch of the vibrating fork will pick up the note of the latter and vibrate in harmony with it. This at once indicates a method by means of which a collection of tuning forks can be made to analyze the various elements in a complex sound. Such a collection or "battery" of tuning forks is shown in one of our pictures. Here the huge fork in the lower left hand corner vibrates only 32 times and, therefore, produces a very low and barely audible tone. At the upper right of

the picture is seen the smallest tuning fork, whose high, thin, piercing note is due to its great velocity of vibration, which is 40,000 per second. Between these limits is a tremendous variety embracing practically every discernible pitch, *i.e.*, rate of vibration.

Tuning forks are among the most important of acoustical instruments; they were invented in 1711 by John Shore, Handel's trumpeter. The fork reached an almost perfect development under the "exquisite workmanship and painstaking research" of Rudolph Koenig of Paris. When properly constructed and mounted it gives tones of great purity and constancy of pitch; it is of very great value in experimental work and provides the almost universal method of indicating and preserving standard pitches for all purposes.

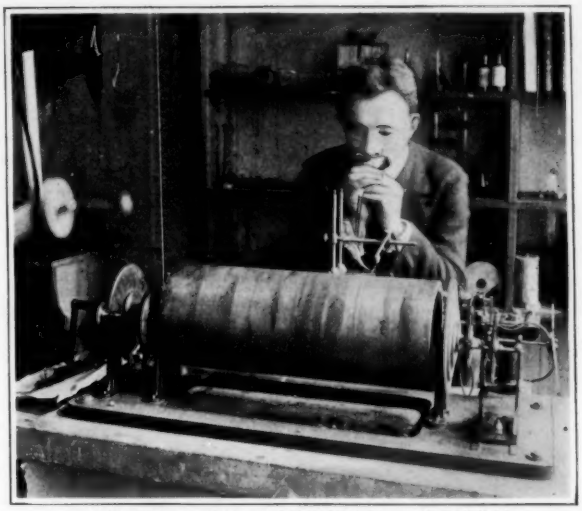
A tuning fork for scientific purposes should be made of one piece of cast steel, not hardened; the shapes developed by Koenig have not been excelled according to our foremost authorities.

The number of vibrations of a fork is dependent upon the mass of the prongs and the elastic force is due principally to the yoke; if the prongs are made lighter, by filing on the ends or sides, the pitch is raised; if the fork is filed near the yoke, the elastic restoring force is diminished and the pitch is lowered. A fork which has a yoke which is very thick in proportion to the prongs, is suitable for high pitches. Experts advise that a standard fork having been accurately machined and finished, should be left with the prongs a trifle too long, that is, flat in pitch; the final tuning should be carried out very carefully by shortening both prongs together till the desired frequency is secured. Filing or grinding a fork will heat it, as will also the touch of the fingers; the heating lowers the pitch of the fork, and if it is tuned while thus heated, it will later be found too sharp, that is, the prongs are already too short. Therefore the filing should stop while the fork is yet two or



A BANK OF TUNING FORKS GIVING PURE TONES RANGING FROM 16 TO 40,000 VIBRATIONS PER SECOND

three tenths of a vibration flat, and the fork should be allowed to remain at a uniform temperature for a day or two before a comparison is made; if further tuning is necessary, it must be done with extreme care, and a comparison again made after another interval of rest. Vigorous filing will produce molecular disturbances which it takes a long time to correct. The boxes on which the forks are mounted act as resinous chambers; the box serves a double purpose in fact: It causes the



A DELICATE SPEECH RECORDING INSTRUMENT

sound to be louder and it also makes the tone clearer, since it reinforces only the fundamental note. Koenig proved that the number of vibrations of a tuning fork is altered by a change of temperature, the temperature coefficient being nearly constant for forks of all pitches, and having the value 0.00011. The change in the number of vibrations is found by multiplying the frequency by this co-efficient and by the number of degrees indicating the change in temperature. The negative sign indicates that the frequency is diminished by a rise in temperature, thus, a fork vibrating 435 times per second at 15 deg. cent. will have its frequency diminished by 0.48 vibrations when the temperature rises 10 degrees.

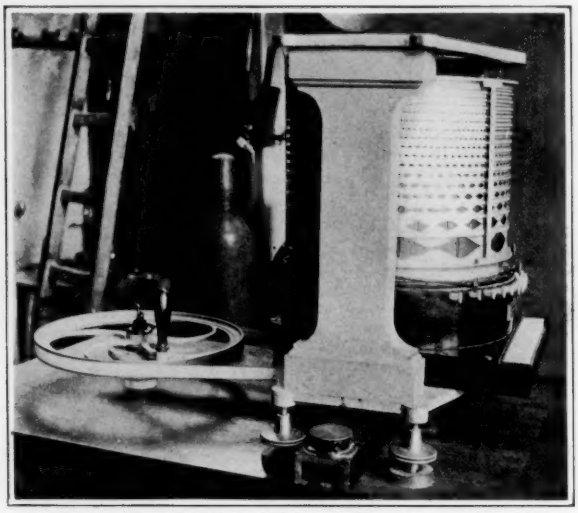
Tuning forks are made to vibrate in various ways. When a very loud sound is desired the bow of a violin may be drawn across the end of one prong. In laboratory experiments it is usual to strike the fork with a soft hammer such as a felt piano hammer head with a flexible handle. Sometimes a rubber ball or a rubber stopper is used, while for a thick, high pitched fork, says D. C. Miller in his recent work, *The Science of Musical Sounds*, an ivory hammer is best. This authority warns experimenters never to strike tuning forks with metal or other hard objects, since being of soft steel they can thus readily be injured.

Sometimes forks are made to give out a continuous sound by means of an electro-magnetic driving arrangement. A fork may be driven by its own vibrations, since when these are once started they produce the necessary interrupted current. Sometimes a fork or a series of forks is driven by an alternating current from another source, such as an outside interruptor fork used to drive a series of ten forks. In the latter case the periods of the forks must be exact multiples of the period of interruptor, since a fork will respond only to impulses in accord with its own natural vibrations.

COMPOSITE TONES PRODUCED BY TUNING FORKS

An extremely interesting experiment to demonstrate the quality of composite tones is described by Dayton C. Miller, the well-known professor of physics at the Case School of Applied Science in Cleveland. To perform the experiment a set of ten forks is arranged in line, each being exactly tuned to the pitches of a fundamental tone having the deep, low note produced by 128 vibrations per second, and the 9 harmonic overtones. Mr. Miller says: "When the fundamental alone is sounding a sweet but dull tone is heard. As the successive overtones are added the tone grows in richness, until the ten

forks are sounding, when the effect is that of one splendid musical tone. One is hardly conscious that the sound is from 10 separate sources, the components blend so perfectly into one sound. The tone is vigorous and 'living' and has a fullness



ROUSSELOT'S IMPROVED FORM OF KOENIG'S WAVE SIREN

and richness rarely heard in musical instruments . . . If, while the forks in the above experiment are sounding, they are silenced in succession from the highest downwards, the tone becomes less and less rich, until finally the fundamental alone is heard. This is a simple tone and is of a dull droning quality; the experiment demonstrates that a *pure tone* is a *poor tone*.

This experiment demonstrates one method in which experimenters can utilize tuning forks to analyze sounds into the fundamental and the overtones which compose them.

The expenditure of breath when vocal sounds are made is very variable, but experiment has shown that in ordinary speech there are certain constant relations. The tambour records made by Rousselot show that the breath expenditure differs at different times of day and also with different activities, as well as with the position of the body, *i.e.*, standing, sitting, or reclining.

STUDYING THE HUMAN VOCAL APPARATUS

Records of the action of the larynx generally refer either to its rise and fall or to the pitch of the tone it produces. The former can be registered by tambours with special projecting arms. The larynx is higher for *a* than for *u*, and lower than for *i*. For *e* it is somewhat lower than for *i* and for *o* somewhat higher than for *u*.

In studying the action of the larynx Rousselot has used a carbon microphone to interrupt an electric current in accordance with the movements of air which accompany the spoken sounds. Instead of a telephone diaphragm the variations in the magnet comprised in the circuit were transmitted to an armature held by a membrane of varnished parchment whose movements were registered by a recording arm. The delicacy of some of these experiments is shown by Rousselot's demonstration that when a German utters the sounds *pa* and *ba* the larynx does not begin to vibrate until much later than when a Frenchman utters them.

Rousselot has also employed a tongue tambour to study the movements of the tongue which assists in the modification of speech. It is also possible nowadays to study the tongue while in action by means of X rays.

The movements of the lips may be registered by a pair of light arms attached to a Marey tambour; an open tube may be placed before the lips to register the breath pressure, and in Rousselot's experiments each lever was made to register separately. The pressure of the lips may also be measured by a small rubber bulb placed between them. Such bulbs are sometimes called exploratory bulbs. They are of various sizes and shapes, being sometimes placed in the nose, sometimes in the mouth, sometimes between the lips, and sometimes in the ear to test the movement of the jaw. Those invented by Rousselot to measure the air pressure in the nostrils are called nasal olives.

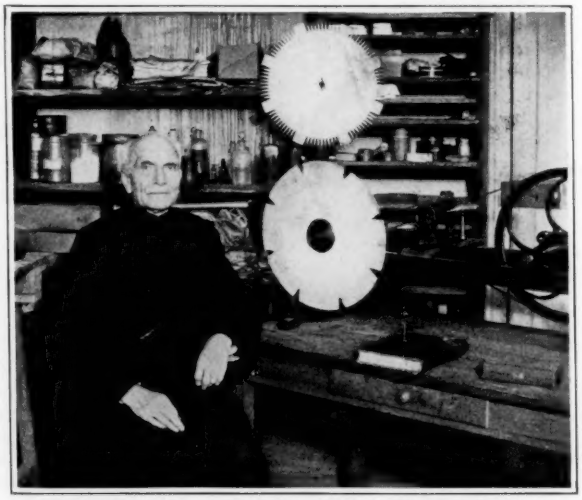
Some of Rousselot's practical applications of his studies have had to do with teaching the deaf to speak—the auditory motor associations being capable, in many cases, of being replaced by visual-motor associations. He has also used the same method for improving the pronunciation of foreigners.

THE SIREN

One of the most valuable instruments for studying sound is the siren. In its simplest form this consists of a metal disk pierced by a circle of holes at regular intervals and carefully balanced and trued. When a jet of air is sent against such a disk while it is in rotation, a series of puffs of air is produced. When the disk goes very slowly these puffs can be perceived separately, but as the speed increases the puffs merge into each other and produce a tone; this tone is at first very deep and dull, but as the velocity of the disk, which is generally mounted directly on the axle of a small electric motor, increases, this tone gradually rises in pitch until it reaches a point beyond which the human ear can no longer perceive it as sound, though it is quite conceivable that certain creatures such as some insects, for example, may have their auditory apparatus attuned to the perception of still more rapid vibration. The rate of the electric motor is regulated by an appropriate resistance, such as a lamp resistance for great changes in speed, and an adjustable wire resistance for smaller changes.

The property of duration in a tone can be illustrated by changing the time during which the tone is produced; the property of intensity by making it louder or weaker.

The pitch of the tone from the siren at any moment can be determined by placing on the axle of the motor a contact consisting of a gear wheel with spaces filled by vulcanized rubber, and adjusting a pair of copper brushes on its rim. A battery current is sent through the brushes, a make-key and a magnetic marker whenever the knob is pressed and each closure will register a check in the line of the marker-point on the drum. To get a registration of the time the marker is connected to a fork in such a way that the breaking of the circuit sets it



THE DISKS USED FOR REPRODUCING VOWEL SOUNDS

vibrating. This can be conveniently done by using the key as a shunt around the marker in a circuit coming from the fork. A comparison of the checks in the line from the marker with the waves of known frequency from the marker will give the

time between contacts at the brushes; from this the speed of the disc and the number of puffs can be readily calculated.

An apparatus known as a "wave" siren was devised by Koenig for producing any desired wave motion. This he did by cutting the shape of the wave on the edge of a disk. He also made a large wave siren for compounding sixteen simple tones of various loudness and phase. Our picture shows an adaptation and improvement of Koenig's siren made by Rousselot.

MAKING SOUND WAVES VISIBLE

The most interesting feature of sound is the quality of its tone and a study of this requires us to consider the form of the wave which produces it. Physicists have sought, therefore, by various methods to obtain visible records of sound. Most of these make use of a sensitive diaphragm to receive the wave motion. A diaphragm is a thin sheet or plate of elastic material, generally circular and supported more or less firmly at its outer edge. Thus in the telephone the vibrating diaphragm is made of thin sheet iron; in the phonograph sheets of mica are often used, and in a piano the sounding board is merely a wooden diaphragm. In laboratory experiments many other materials are employed, such as paper, parchment, rubber, a film of soap suds, metal, glass, gelatine, etc.

As we daily prove when we talk into a telephone with a good connection or listen to a phonograph, diaphragms are remarkably sensitive to an immense variety of combinations of tones covering a very wide range of pitch.

The Phonautograph.—In 1859, the Scott-Koenig phonautograph for directly recording sound waves was perfected. It consists of a membrane placed at the focus of a parabolic receiver or sound reflector; to this membrane a stylus is attached and in front of the stylus is a drum carrying a roll of smoked paper. Any sound produced in front of the receiver causes the membrane to vibrate in harmony with its wave motion, and these vibrations are recorded upon the smoked paper. A tuning fork is mounted on the base of the instrument in such a manner that its prongs are between the membrane and the paper. A stylus attached to one prong of the fork marks a simple wave line by the side of the tracing made by the membrane. In this manner Koenig obtained a number of comparative records, in which the tracing made by the tuning fork lies directly above that made by other instruments, such as voices, combinations of organ pipes, etc. But these records are very small and are apt to be distorted or even obliterated by friction and by the momentum of the recording point.

The Manometric Flame.—Three years later Koenig made a brilliant invention which has been much used ever since in the form of a "manometric capsule," in which the flame of a gas jet vibrates in response to the variations of pressure produced by a sound wave. Still later Professors Nichols and Merritt suggested the use of acetylene gas, thus making it possible to photograph the flame. Some very beautiful illustrations of wave motion are obtained in this manner and these records can be filed and compared with others whenever necessary.

Motion Pictures Shown in Relief

The Glypho-Cinematograph for Producing Stereoscopic Effects

A FRENCH physician, Dr. J. L. Pech, connected with the Faculty of Medicine at the University of Montpellier has recently propounded a novel theory with regard to the reason why under certain circumstances the eye obtains three-dimensional effects. It has long been held by men of science that binocular vision, *i.e.*, vision in which the two eyes focus together is the principal reason for our perception of objects in relief? This hypothesis has failed to satisfy Dr. Pech for four reasons, which may be stated as follows:

I. Looking at pictures through a stereoscope rapidly induces fatigue and headache, thus indicating that there is somthing physiologically abnormal about this method of obtaining impressions in relief.

II. Stereoscopic relief differs from that perceived by the unaided eye; the latter sees objects in their primary planes in alto-rilievo, *i.e.*, in the round followed by successive planes and not as a series of silhouettes without thickness, clearly defined against a background formed of a single plane, as is the case in the vision of stereoscopic images.

III. The study of the phenomenon described by Helmholtz under the name of "antagonism of visual fields" leads us to believe that the total perception of two visual fields which is required for vision through a stereoscope, is not a normal physiological phenomenon.

IV. Many persons who have been blind in one eye from birth have no difficulty in perceiving perfectly the objects they look at in relief, just as do normal persons.

These considerations induced Dr. Pech to make a study of the subject which led to some interesting results. To begin with he found in the course of his researches that there are a number of methods by means of which a single eye may become capable of receiving an impression in relief. Writing in *La Nature* (Paris) for January 29, 1921, he describes some of his experiments along this line.

He found first that an ordinary photograph produces this sensation of relief on being examined by one eye when it occupies the entire visual field, because of being placed farther from the eye than the nearest point at which distinct vision is obtained.

Again it produces this effect when seen by reflection in a concave mirror having a focus of about 1 meter, especially when the mirror is parabolic in form.

Thirdly, the same result is obtained when the photograph is examined through a powerful double convex or plano-convex lens whose spherical aberrations have not been corrected.

In all these cases, says Dr. Pech, the sensation of relief is exactly like that obtained by ordinary eyesight instead of being exaggerated as in a stereoscope.

These interesting observations led Dr. Pech to form the following conclusions:

I. An ordinary checker board marked off into squares by straight lines, produces upon the retina, when it occupies the entire visual field (thus causing a relaxation of the function of accommodation), an image having curved lines instead of straight lines, as shown in the diagram of Fig. 1. This is a well known fact long ago observed by such prominent men of science as Helmholtz, Tscherning, etc.

II. Since a plane photograph is seen with a marginal distortion, either because it occupies the whole of the visual field, or because it is seen as reflected or refracted by such a mirror or lens as is described above, it seems reasonable to suppose that these marginal distortions may be an important factor, hitherto unrecognized, in producing the impression of depth, commonly called relief. Dr. Pech next proceeded to test the correctness of this ingenious theory by means of actual experiment. He first endeavored to obtain a distorted image, which, being large enough to be seen at a distance of 6 or 7 meters, would cease to exhibit distortion and furnish the sensation of relief. But in practice it is not possible to obtain photographic images exhibiting similar distortions by means of uncorrected lenses. It is necessary, therefore, in order to obtain an image which shall be clearly defined at all points to have a sensitive plate possessing a curved form similar to that of the back of the ball, so as to coincide with the focal

surface of the lens. The inventor's next step, consequently, was to prepare by means of preliminary calculation screens of such curvature that a photographic image projected upon them would make upon the eye of the spectator the same impression as is made by the real objects themselves upon the naked eye, when so placed as to cover the entire visual field of the observer.

These screens, to which the name of glyphographs (from the Greek words *glyph*=engraving, and *graph*=inscription) has been given, are formed by stretching a sheet upon a frame whose edges are hyperbolic in a plane which is perpendicular to the surface of the screen, as indicated in the diagram shown in Fig. 2. By means of a rather complex formula, the inventor succeeded in calculating the perimeters of the hyperbolas in proportion to the dimensions of the screen.

These glyphographs of Dr. Pech have already come into

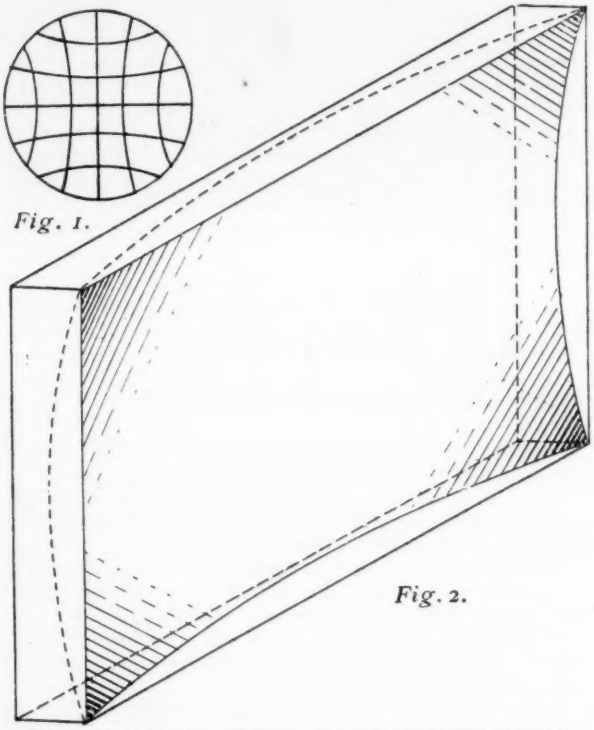


Fig. 1.

Fig. 2.

FIG. 1. IMAGE OF A CHECKER-BOARD UPON THE RETINA.
FIG. 2. THE GLYPHOGRAPH SCREEN

fairly extensive use both in this country and abroad, and according to experienced cinematographers possess the following advantages:

I. The images projected upon these screens give a true impression of depth without any apparent distortion.

II. The images are clearly defined at all points and have a uniform illumination because of the fact that the screen occupies approximately the location of the focal surface of the projecting lens.

III. Even when seen from positions very close to the screen and greatly to one side the images are not unpleasantly deformed as is the case when a plane screen is employed.

IV. Moving pictures are much less fatiguing to the eye of the spectator when seen upon such a screen.

Dr. Pech admits that many other investigators in various countries have previously patented screens of spherical, cylindrical, or prismatic form, but he claims that none of these has produced satisfactory results, since in none of them were the preliminary calculations correct, as in all cases they failed to take account of the essential factor involved in the peculiarities of the human retina. In other words the superiority of the Pech screen consists in the fact that it is not only based upon calculations respecting the focal surface of the projecting lens, but takes into account also those distortions of the image formed upon the retina which are due to peculiarities of the refractive lenses contained in the human eye.

THE OPTICAL INDUSTRY

FROM time to time notice has appeared in the press relative to the importance of our optical industry and that this is not confined to the United States is evident from an article in *Nature*, February 10, concerning the promotion of the British optical industry. The British Government has promised to introduce in the House of Commons at the next session a bill to safeguard and foster certain key industries and of these optical glass and optical instruments are to be given special consideration. Industries of this type because they are relatively small, not employing large amounts of capital nor great numbers of employees, are likely to be overlooked. It is, of course, dangerous for any nation to estimate the value of a particular industry by the amount of capital invested or the number of people employed.

In Great Britain, as elsewhere, the scientific industries are exposed to most skilful German competition which is now more of a menace than ever due to the rate of exchange. It is unusual to have a British industry consider protection essential to its life, but the optical glass and instrument industries through their association now ask that the following measures of protection be provided:

(1) No optical glass or scientific instruments to be imported to the country for a period of seven years except under license.

(2) Such licenses only to be granted in respect of goods which are not being made in Great Britain in the required quantities or of the required quality.

(3) An expert licensing committee to be set up.

(4) The optical instrument manufacturers are prepared in order to guarantee reasonable prices to submit to a control of profits.

That the manufacturers are taking due measures to promote scientific research and improve their product is guaranteed by the fact that a scientific instrument research association has been formed by the leading manufacturers as an educational activity to their research already carried on in their own establishment.

IMPROVEMENTS IN DYEING

IN discussing the work of the dyer and cleaner before the Rochester Section of the American Chemical Society, Mr. E. B. Leary recently pointed out that the old method of matching certain colors in order to duplicate an order was to dye several samples of yarn at the same time the fabric was being dyed. But this method is rapidly becoming displaced by the use of a new type of colorimeter. With the aid of this instrument the shade and hue of the color to be matched are determined and recorded according to a series of arbitrary numbers which correspond to the numbers of standard color filters and wedges used with an ordinary daylight lamp. By the use of such an instrument the merchant may order fabrics to be dyed in accordance with numbers stated by him, thus eliminating the former dependence upon the measure of the shade by the use of fanciful trade names which are too inaccurate to serve as a guide for dyeing.

Mr. Leary also pointed out that, whereas in the past the dyeing has been in the hands of craftsmen who were without scientific training and who learned their trade by apprenticeship with all its many secrets, today the dyer is technically trained and capable of using the many delicate scientific instruments being developed for his assistance.

Incidentally, it is interesting to note that two decades ago the quantity of dye required to dye a woman's dress was about four times that required today. This is largely due to a change in style including the weight of the fabric.

PREPARING THE ORIENT ESSENCE IN THE LABORATORY OF AN AMERICAN ARTIFICIAL PEARL FACTORY

Artificial Pearls

"Orient Essence" of American Manufacture

By T. A. Marchmay

IMITATION is the sincerest form of praise and by that token there is perhaps no natural product so much admired by man in every age and among every race, savage or civilized, as the pearl, the queen of gems, surpassing even the diamond in its appeal. The supply of pearls formed naturally has never sufficed to meet the demand. Pliny speaks of the trade in pearls, "the most precious commodity of the world." But it was doubtless before Pliny's time that the Chinese, the discoverers of so much that has since been rediscovered in the Occident, endeavored to make two pearls grow where one grew before by introducing bits of gravel, etc., —even on occasion tiny images of Buddha—into the shell of the oyster in order that the animal might be forced to protect its tender tissues from irritation by covering the foreign body with a coating of nacre. Certain natives of the South Seas have an even similar method, so they believe, of producing pearls artificially. To these simple souls the pearl is a sentient thing, with a personality of its own, and those powers of reproduction which other sentient beings have. In pursuance of this theory, and regarding seed pearls as the offspring of larger pearls, it is their custom to select two fine specimens and place them together in a closed vessel, together with a few grains of rice, and it is their solemn belief that if all goes well, when the vessel is opened a few months later, it will contain not only the original pair but a number of seed pearls, the offspring of the former, while the rice will be found to have its edges nibbled! This same superstition holds sway in Borneo, but in that island the conditions of this singular experiment in breeding are rather more difficult to carry out. Pearl divers regularly put aside every ninth pearl of suitable size, placing the collection in a bottle, but it is an absolute *sine qua non* that the neck of the bottle be stopped with a dead man's finger, and Mr. George Kunz tells us that in a certain locality all the graveyards for miles around have been robbed with this ghoulish design! Strictly speaking, however, imitation pearls such as the images of Buddha described above are rather *artificially bred* pearls than artificial pearls proper. The latter are fashioned by the hand of man, of various substances, including wood, wax, stone, plaster, glass, etc., and then coated, in most cases at least, with a special pigment to give them the appearance of true Orient pearls.

The pigment *par excellence* which produces this effect—the soft luster of the moon livened by the delicate colors of the dawn—is the Essence d'Orient, also known as Orient Essence and as Pearl Essence. For the discovery of this natural pigment we are also indebted to the Chinese. The first artificial pearls to which pigment was applied in Europe were made in France and consisted of small balls of plaster, covered with a paste prepared from the scales of the white fish or bleak mixed with glue. The pearls made in this manner were very handsome indeed while they reposed in the jeweler's box, but when they were worn by the fair recipient, the heat and moisture of her body, alas! caused the glue to melt so that the silvery color ran off, leaving the necklace to look like fragments of a ruined fresco.

SCRAPING THE SCALES OFF A SEA HERRING

But in 1680 an ingenious French maker of rosaries at Paris, named Jacquin, conceived the idea of making the body of the false pearl of glass. The process he employed is practically that

which is in use today, with certain modern improvements, of course, but essentially the same in principle, *i.e.*, a coating of thin hollow globes of glass with a paste made from iridescent fish scales.

One of the modern improvements is the imparting of an

A GROUP OF GIRLS FORMING THE GLASS BEADS WHICH FORM THE BASE OF THE ARTIFICIAL PEARL

opalescent tint to the glass employed by means of a careful treatment with hydrofluoric acid.

THE MAKING OF ORIENT ESSENCE

As stated before in this article, the pearly sheen and the delicate play of color found in real pearls of fine orient, are imparted to their false but fair *simulacra* by means of a preparation made from the scales of certain fish and called in French Essence d'Orient and in the American trade Orient Essence, or Pearl Essence. Not all fish scales are equally suitable for the preparation of this product. Hitherto, it is the scales of the small white fish, known as the bleak, very generally found in the stream of Europe, which have been found best suited for this purpose. In both Germany and Italy these fish have been caught on a very large scale merely with the object of making this essence. The writer has been told recently, however, that the finest material was imported to France from Russia. The Russian débâcle has naturally played havoc with this supply as with so many other valuable Russian exports, consequently, not only French manufacturers of fine artificial pearls have found their supplies cut short, but American manufacturers were in despair of getting any at all. As a consequence they besought the aid of the government to find an American substitute. The happy result of the researches undertaken at their request, under the auspices of the Bureau of Fisheries, has been the notable discovery that the scales of the shad and of the sea herring are capable of furnishing as choice a product as those of the bleak. Already, it is said, the fishermen of the Chesapeake have turned this discovery to commercial account.

As soon as the fish are taken out of the water they are carefully washed in fresh water to cleanse them of mucus and mud or dirt and then allowed to drip, after which the small scales which cover the outer surface of the skin are scraped off either with a sort of wooden spade or by rubbing two fish together, great care being taken to keep them from being soiled by blood and to have them free from adherent bits of flesh. Since they readily spoil if allowed to lie, undergoing a putrid fermentation attended by an offensive odor, they are promptly placed in a receptacle containing water to which there has been added either 15 centigrams of chloride of silver or else 3 gr. of salicylic acid. Five kilos of scales are required for the preparation of 1 kilo of the essence and to furnish these not less than 38,000 to 40,000 bleak fish of average size are needed. The scales from the back and the belly are kept apart, since the latter are the finer and bring a better price on the market. Before the war this was about 25 fr. per kilo.

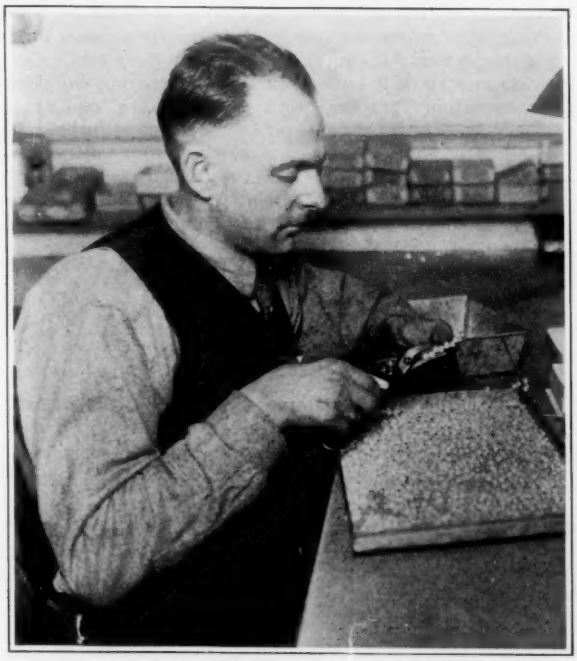
When a sufficient number of scales has been collected to justify manufacture, the water covering them is decanted and a suitable quantity of the scales is placed in a large flat mortar made of glazed porcelain. By means of a peculiarly shaped flat pestle the operator proceeds gently to crush the scales, being careful to move the pestle backward and forward instead of around. In this manner they are separated into longitudinal laminæ. As a result of this crushing process the small particles of matter, which impart to the scales their characteristic silvery aspect are gently and gradually detached. After several hours of this treatment pure water is poured into the vessel containing them and they are carefully triturated therein. The silvery particles are reduced by this treatment to a state of extremely fine division, and are extremely light, so that they are held in suspension in the water or else float upon its surface. The mixture is then strained into a tall vessel through a piece of fine linen stretched over its mouth. The water containing the silvery

APPLYING THE ORIENT ESSENCE WITH THE AIR BRUSH

BURNISHING THE PEARL BEADS ON CHAMOIS POWDERED WITH FRENCH CHALK

pigment passes through the meshes of the linen while the scales which have been partly stripped of their coloring matter remain upon the cloth. These scales are put through the same process once more, being bruised and triturated in water, and the latter filtered as before. The double operation is generally sufficient to remove all the pigment.

The filtration liquid is then stirred by means of a mechanical device for five or six hours, after which it is allowed to settle. The pigment collects rapidly at the bottom of the vessel and the water above it is decanted. The moist mass of pigment remaining has a brilliant luster and a charming silver white color; after being dried it yields an extremely fine powder of a grayish silver tint. This is the orient essence and like the scales from which it came it can be



CLIPPING THE BEADS OFF THE WIRES

preserved indefinitely in water to which a small percentage of silver fluoride or salicylic acid has been added. In pure water, on the other hand, it rapidly putrifies and loses its color.

COVERING THE PEARL BEADS

Making the Pearls.—The foundation of an artificial pearl is a small sphere of blown glass. These spheres are obtained from a very thin tube of glass more or less opalescent in tone. Very varied forms can be obtained closely imitating the variety found in natural pearls, but this work must be entrusted to highly-skilled glass blowers, since the wall of the bead must be both extremely thin and very even in its thickness.

Coating the Beads.—In order to be applied either to the inner surface or to the outer surface of the glass beads thus prepared, the orient essence described above must first be mixed with gelatine. White gelatine is used—in France that bearing the trade-mark Coignet. This is first put to swell in water to which 3 per cent of salicylic acid has been added for half an hour, and is then placed in a water in a porcelain vessel where it is very carefully melted after the acidulated water which covered it while it was swelling has been poured off. When entirely dissolved 10 to 12 gr. of the orient essence are added to 10 gr. of the gelatin solution and the two are very carefully mixed together until a perfectly homogeneous product is obtained. This mixture is kept in a fluid state upon the water bath and by means of a pipette tapering to a fine point one or two drops of the preparation are inserted in each hollow ball of glass by means of a small perforation. As soon as this coating has been introduced into the pearl the latter is thrown into a sort of glass cup mounted upon a centrifugator revolving at 1,200 revolutions. The rotary motion thus imparted causes the solution of gelatine and pearl essence to be spread thinly and uniformly on the inner surface of the hollow bead. Here it quickly dries, having upon cooling a hardness like that of cement. Sometimes the pearl essence is spread upon the inner surface of the bead merely by skilful blowing of the operator's breath, in which case the centrifugating apparatus can be dispensed with.

Sometimes the pearls are left hollow, in which case they are naturally very fragile. In the better wares, however, as soon as the coating of essence has hardened properly, the pearl is filled with a mixture consisting of 80 parts of wax and 10 parts of sulphate of baryta, the latter being added to give the pearl a weight approximating that of the natural gem. This filling is accomplished by means of a tapering pipette, the mixture being kept warm at a temperature of about 35° C. upon a water bath.

PEARLS OF SOLID GLASS

Sometimes the pearls are made of solid glass, in which case the pearl essence must be applied to the outside. According to a well-known authority, Maurice de Keghel, former

SORTING THE BEADS ACCORDING TO SIZE

head of the laboratory of the Institute of Applied Sciences, in Paris, most of the famous pearls noted for their marvelous duplication of the genuine gem are made of opaque solid glass, covered externally with orient essence.

In this method of treatment two solutions or rather emulsions of pearl essence are employed, one of which is slightly gelatinous while the other is prepared with acetone. The operator has in front of him small aluminum wires 5 or 6 cm. in length and about 0.5 mm. in diameter, and tapering at each end. One of these is inserted in each pearl as a sort of handle in the threading hole; the operator then dips the pearl in the emulsion of orient essence and rapidly withdraws it, after which he or rather she inserts the opposite end of the wire in a sheet of cork, so that it shall be in as absolutely vertical a position as possible. This causes the pearl essence to spread itself uniformly over the bead while the excess runs down the wire stem. As our picture shows, the pearls now look like white currants on long upright stems. They are allowed to dry in a vertical position, and then each pearl is

dipped in the same manner in the acetone preparation of the orient essence, being again withdrawn with great rapidity and its stem inserted upright in the cork. The acetone evaporates in a few moments and leaves a silvery white iridescent coating indelibly upon the surface of the bead. When very handsome pearls are to be produced this process of alternate dipping and drying is repeated a number of times, even as much as thirty or forty. In recent practice, as shown in one of our engravings, the coating is applied by the use of the air-brush. The orient essence is thus applied very smoothly and of any thickness desired.

When finished their resemblance to genuine pearls of the finest orient is very remarkable. An illustration of this was noted by the writer during a stay in London some years ago. A magnificent necklace of pearls valued, if I remember rightly, at something like $60,000, was on display in one of the cases at Christie's, previous to being offered for sale at that famous auction room. This necklace was the object of admiring attention on the part of a woman of marked distinction and elegance of attire. She came repeatedly to hang over the case in which it lay, and finally, a day or so before the auction was to take place, remarked to the attendant that she thought of bidding upon it, but would like the privilege of examining it for a moment outside the case. The request was granted; she thanked the custodian and swept gracefully away. While there had apparently been nothing suspicious in the transaction, a sudden misgiving smote Christie's man for some reason, and he hastily despatched one of the detectives at hand. The latter caught up with the lady upon the sidewalk and despite her protests insisted upon her return and that a search of her person be made, whereupon it was promptly revealed that she was carrying away with her the genuine necklace for which she had substituted a marvelously faithful imitation prepared by an accomplice from the description which her previous close study of it had made possible. It may be remarked, however, that close as is the imitation there is a difference in the weight which helps the connoisseur to judge between the true and the false.

It is of great importance that the pearl essence employed should be as fresh as possible without the slightest sign of alteration. To test its perfection a trace of formol is added. If the gelatine emulsion is not fresh it rapidly becomes turbid, while the pigment loses its luster and has a flaky look. Under such circumstances it is unfit for use in preparing fine pearls. It is important that the acetone emulsion be kept in the dark and the mixture must never be stirred or disturbed when it is about to be used. Under these circumstances there will be a layer of acetone on top of the pearl essence, and this is necessary. When orient essence is too old it is coarser grained and produces a less perfect imitation.

Typewriter Inks and Ribbons*

An Interesting Review of Some German Methods of Manufacture

BEFORE the War, the manufacture of typewriter inks and ribbons formed an important industry in Germany. Much of the products was exported. In the United States, the consumption of these commodities is very large. The ribbons are made generally by the large concerns which manufacture writing machines, as an adjunct to their main business, while the inks are produced usually by factories which are engaged in the general manufacture of inks and colors. The secrecy with which this manufacture has been surrounded, and the little that has been published concerning the process and formulæ used, make this article, which is concerned with German practice, very interesting.

There are two distinct branches of the manufacture. The first is concerned with the making of the inks, and the second with the impregnation of the ribbons with these inks.

TYPEWRITER INKS

The qualifications of a good ink are as follows:

1. It must be made in such a manner that neither acids nor alkalies are used in its making, or at least in as small amounts as possible. This is important, for the metallic type in the machine must not be corroded or blurred in any way.
2. The ink must not foul or decompose in the ribbon.
3. The ink must impregnate the ribbon in such a way that it yields its color easily, that is, the ribbon must print well. The facility and regularity with which this is accomplished are the determinate factors in the life of the ribbon.

FAST INKS

In former times, inks for writing machines were made in the same manner as those for stamp pads. For example, a much used process for making the ink consisted in dissolving various aniline colors in glycerine and then adding water, according to the following formula: 50 to 100 parts of the aniline color, 800 parts of glycerine and 200 parts of water. The ribbons impregnated with this ink yielded strong distinct impressions, which, however, could not be copied. A great disadvantage of ribbons made in this manner lay in the fact that, when the air was humid, the impressions were indistinct, due to the hygroscopicity of the glycerine, which resulted in the ribbons absorbing considerable water.

A way of correcting this defect was found in compounding the ink in a fatty solvent. This was accomplished by dissolving the coloring matters in hot oleic acid, and adding thereto mineral oil, free from acid. To produce a black ink, nigrosine was used, and various basic dyes and colors trademarked "Ceres" were used for the colored inks. The impressions, made with these inks, cannot be copied.

MORE MODERN PROCESSES

At the present day these processes have been abandoned almost entirely. Ground colors are used generally. To obtain these, cylinder grinders must be used, as the ordinary mortars do not yield a product of sufficient fineness and are incapable of furnishing the inks in large enough quantities. Funnel mills cannot be used, as their grinding action does not yield a fine enough product. Even in the use of the cylinder mills, it is essential to repass the materials through the apparatus several times or at least three times, before it is certain that a pigment of the proper degree of sub-division has been obtained. The finer the grinding the better the quality of the ink. A convenient practical test for ascertaining if the ink has been ground long enough consists in placing a little on a piece of paper and rubbing it over with the finger. If the ink seems to lack uniformity, that is, if the streak of color on the paper shows light and dark spots, then the grinding has not been allowed to proceed far enough and must be continued.

To make black ink the finest lampblack is employed. In the colored inks pigments of all sorts and particularly the aniline colors are used. Mineral colors such as prussian blue and various cinnabar substitutes[1] can be utilized, provided they are ground very fine.

All the pigments are ground in vaseline of the best quality or else in a thick mineral oil. To obtain a medium of greater

*Bruno Walter, *Chemiker Zeitung*, 1921, 21, 169. Translated from the French version in *La Revue des Produits Chimiques*, 1921, 119-120.

[1]Cinnabar or mercury sulphate, also known as vermilion, is too expensive to be used for making red colored typewriter inks. Instead cinnabar of antimony is used considerably. This substance is $(Sb_2S_2O)_2$. It is found in nature and is prepared artificially as well. The process consists in treating (antimony chloride) $SbCl_3$ with $No_2S_2O_3$ (hyposulphate of soda) or in heating antimony sulphide in a current of air and steam.—EDITOR.

viscosity about 5 to 10 per cent of mineral wax is added. After the grinding has been brought to the proper point, according to the above test, then about 10 per cent of an oleic acid solution of the pigment ground in the same oil, or rather fatty substances, is added and the mass is mixed very carefully and then put through the grinding mills once again. A typical formula of a black ink is as follows:

Ten parts of very high grade lampblack are ground several times (twice is sufficient for the most part) with 40 parts of odorless vaseline of the best quality. Then 5 parts of a solution of nigrosine in oleic acid are incorporated with the above. The nigrosine solution contains about 50 per cent. of the dyestuff. The mixture is then ground once more. This ink is suited particularly well to the writing of deeds and other important legal documents, as it does not attack the paper and is very resistant to chemical as well as mechanical influences.

The procedure in the manufacture of colored ink is entirely different. Very often after the ink has been compounded, it is necessary to correct the color. A dark color, ground in vaseline or a similar suitable medium will give an impression in the typewriter that is not, for example, blue or violet, but black. When this happens, the pigment must be diluted. This is done generally with the aid of zinc white (finely ground zinc oxide). Sometimes, the shade of the ink is not exactly what was wanted, as for example a green may have too much blue in it. Then, the color may be modified by the admixture of the proper pigments. The amount to add is determined best by practical tests. It is preferable to mix the pigments together in the dry state, before compounding them with the vaseline or the mineral oil, and then after the proper shade has been obtained to put them through the grinding mills. All these inks are not suitable for use where it is desired to make copies of the impressions obtained with them.

COPYING INKS

Aniline colors, that are soluable in water, are substituted for the insoluble pigments in the manufacture of copying inks for use in writing machines. The colors, which are most suitable for this purpose, are the basic dyes, such as: Methyl violet, methylene blue, malachite green, safranine, etc., etc. They are ground in vaseline, which in this case is much more suited to the purpose than the mineral oils. The paste that is obtained in this way is ready for use without the addition of the colors ground in oil.

The impressions made with these inks, are dull, but they assume a brighter tone when they are copied.

In certain factories, they use castor oil or sesame oil instead of vaseline. The following composition of a copying ink is given in a rather old German patent (German patent No. 71,912): Twenty-four parts of the pigments compounded with tar oil are dissolved in 4 parts of castor oil, 2 parts of creosote or phenol and 2 parts of Cassia oil.[2] Other inks are made with saponified oils in which the aniline color is dissolved.

HECTOGRAPHIC INKS

The hectographic inks must include glycerine in their composition. In this case, the inks must be more concentrated than the ordinary inks, for the impressions made with them must yield 50 to 100 copies. To make an ink that contains large quantities of the pigments requires special care in the selection of the dyestuffs and the dilutents and other additional ingredients in order to prevent the colors from crystallizing out of the solution. As far as the intensity of the pigments or dye is concerned, the manufacturers can furnish the necessary information, but the means of preventing the crystallization of the coloring matters are determined best by actual experience. Then we may be reasonably sure of obtaining accurate results. It is known that the addition of acids to the composition increases the solubility of the organic coloring matters. Accordingly, muriatic, or better, the chemically pure hydrochloric acid, is employed generally for this purpose, because of its relatively greater volatility. In using this acid or others of like nature, the deleterious action of acids on the typewriter must be taken into consideration.

A very good ink is obtained in accordance with the following formula: One hundred parts of crystallized violet are dissolved in the hot in 300 parts of 28 degrees Be. glycerine and 190 parts of water. After solution has been effected, 60 parts of hydrochloric acid (20 to 22 degrees Be.) and 50 parts of an aqueous solution of dextrine are added (the dextrine solution contains 50% dextrine).

The action of the dextrine is to facilitate the hectographic printing and to prevent the ink from being absorbed by the paper too copiously. The ribbons, impregnated with this ink, lose the greater part of their acid content rapidly, but retain enough of it to render it necessary to wash the type of the machine carefully, each time the ribbon is used.[3]

TYPEWRITER RIBBONS

It is of prime importance that the ribbon itself be of the best quality. The early ribbons were made from closely woven silk. In present day practice, the ribbons are made exclusively from cotton fabric, manufactured especially for this purpose. It is very essential that the fabric be strong and of a closely woven texture. The ribbon should be free from stiffness and the edges should be woven in such a manner that they do not travel and resist all the mechanical wear and tear that they receive in passing through the different parts of the typewriter. The different sizes of writing machines on the market require that they be made in various widths and lengths.

A method of impregnating the ribbons, which was used very considerably in former times and is used to some extent even at the present time, consists in passing the ribbon through a bath of the ink. The new ribbon is wound on a spool, set a certain height above a shallow vessel containing the ink. The ribbon passes through the ink bath under two rollers, placed at either end of the vat, which keeps the ribbon under the surface of the ink in its course through the bath. The ribbon leaves the vat at the farther end and then is passed between two cylinders, which serve to force the adhering ink into the pores of the fabric and also to rid the ribbon of all excess ink, which flows back into the bath. The finished ribbon then is wound upon another spool. The ribbons, made in this manner, give strong, clear impressions, but after being used a short time, they lose their ink almost entirely, long before the ribbon itself has worn out.

In order to prevent the effectiveness of the ribbon from being destroyed in such short order, the ribbons are no longer impregnated with the ink, but a very thin coating of the ink is fixed on both sides of the ribbon. This coating is so thin that the type in the writing machine neither becomes dirty nor yields blurred impressions. To make such ribbons only inks ground to the consistency of a paste can be used. The new ribbon is passed between two rollers, one of which is smeared with the ink and the other presses the ribbon against the inked roller and causes a coating of the ink to form on the ribbon. The other side of the ribbon is coated in the same way later on. The finished ribbons are wound on the well-known spools or reels, either mechanically or by hand, while passing through measuring devices, which cut off the ribbon at the proper lengths. This method of manufacture is preferable to the first, because the process can be regulated more easily and a more uniform product can be obtained. The finished ribbons are sold in metallic boxes provided with tight fitting covers so as to exclude the air as much as possible, as this tends to cause the ribbon to dry up.

[2] Cassia oil is an important essential oil, distilled from the bark, leaves and twigs of a shrub indigenous to Cochin-China. It is called erroneously cinnamon oil in the U. S. P. The active constituent is cinnamic aldehyde which is made synthetically as well.—EDITOR.

[3] A red hectograph ink which gives good results contains 20 parts of magenta, 20 parts of alcohol, 5 parts of acetic acid, 20 parts of gum (arabic) and 40 parts of water, or else 10 parts of magenta, 10 parts of alcohol, 10 parts of glycerine and 50 parts of water.—EDITOR.

True Nature of Soap Solutions*

New Concept Destined To Be of Great Service in Investigations of "Colloidal Electrolytes"

SOAP solutions have been used by civilized peoples for many hundred years; strangely enough, however, the reason for their action and their actual chemical and physical nature have remained exceedingly obscure until quite recently. To begin with, nobody knew why the detergent power of soap suds, *i.e.*, their ability to wash cloth, etc., clean was greater than that of any other known substance—a fact which was abundantly proved in the war when the lack of soap was greatly felt in Central Europe. The theory of Chevreul that this power depends upon the emulsifying and suspensory character of soap solutions has recently come to the forefront once more through the support given it by Hillyer Spring and other investigators. This quality is in its turn dependent upon the remarkable lowering of the superficial tension of water when soap is dissolved in it, as respects oily fluids or solid particles such as rust, smut, and dirt in general. This lowering of the surface tension makes it possible for soap solution in contrast to ordinary water, to creep in between spots of dirt or stains of oil and surround them so that they can be easily washed away by the rinsing water. The apparently much simpler question as to the constitution of soap solution has been the subject of study at the University of Bristol by McBain and his students, for the last ten years, and these experiments have now furnished a satisfactory explanation of the matter which involves an entirely new concept with regard to the constituents, not only of soap solutions, but, apparently, also applicable to the comprehension of certain albumins, dyestuffs and other high molecular compounds.

The somewhat contradictory theories of earlier investigators were incapable of explaining the manner in which soap dissolves in water, whether in a crystal or a coloid condition and whether split up through hydrolysis or electrolysis. All these questions it is now possible to answer by means of the data obtained from the numerous series of measurements made, not only with respect to genuine soap solutions, *i.e.*, those made from the alkaline salts of the highest fatty acids, but also in the case of the entirely homologous series of the fatty acid alkalies as far down as the acetates—and this at all practicable concentrations and temperatures. To begin with the measurement of the *electrical conductivity—i.e.*, at 90° cent.—revealed two surprising facts: A comparatively high degree of conductivity even in very strong soap solutions, and a very curious behavior of the conductivity with respect to the concentration—*e.g.*, while in the case of acetates the equivalent conductivity slowly and regularly decreases as the concentration increases (which corresponds to the gradually decreasing electrolytic dissociation), in the case of the laurates, and still more in that of the myristates, palmitates and stearates, (*i.e.*, the chief constituents of soap). While the decrease is very great at first, in about 0.1 normal solutions the equivalent conductivity increases with the concentration up to about 0.5 n, and not until the higher degrees of concentration are reached does it again exhibit a slight falling off.

At first this remarkable behavior was ascribed to a hydrolytic cleavage of the soaps; McBain, therefore, sought to find a solution for this much debated problem and succeeded in doing this in two ways. He proved both by electrometric measurements with hydrogen electrodes and by means of a determination of the velocity of reaction of a certain decomposition accelerated catalytically by means of alkali in the presence of soap solution, that the concentration of the free OH-ions in soap solution vary according to their concentration only between 0.001 and about 0.003 of the normal; the degree of hydrolysis in a 1-normal soap solution—0.1 per cent and even in a 0.01-n-solution, amounts to only a little over 6 per cent. These experiments prove definitely, therefore, that the fable of an *extensive* decomposition of the soaps in three fatty acids and free alkali is entirely incorrect, and that the hypotheses based upon this theory must be likewise false—such a hypothesis being the explanation of the detergent action. (Furthermore, when there is a hydrolytic splitting up of the soap in the presence of free alkali it is not free fatty acids which are formed but compounds of these with neutral soaps in constantly changeable relations to acid soaps.)

This small amount of splitting off of free alkalis is not capable, as the calculation showed, of explaining the anomalies which are exhibited in the phenomenon of the electric conductivity of soap solutions, hence we must seek some other way to elucidate this. For this purpose we may turn to the physico-chemical processes of *molecular counting* which are based upon the fact that the osmotic pressure and the properties of the solution which depend thereon—vapor tension, boiling point, freezing point, etc.—are proportional to the number of the molecules in one unit of volume of the dissolved substance. Measurements of the boiling point of soap solution are not feasible, as McBain has shown, because it is not practicable to free the soap suds from air, and on this account the partial pressure of the water vapor remains too low. Direct measurements of the vapor tension by means of the tensimeter are very laborious. It is true that measurements of the freezing point can be made, but only in the case of the oleates and the lower fatty acid salts which continue to form homogeneous solutions at 0° cent. By far the greater number of measurements were made by a method which has hitherto been but little employed, but which has been worked out by the authors with great precision; this method is known as the *dew point*. In this method a polished silver cylinder is suspended in the saturated vapor of a soap solution which has been heated to a temperature of 90.00° cent., the silver cylinder being traversed at the same time by a current of water heated to precisely the same temperature as the vapor; when the temperature of the soap solution falls even for a very few tenths of a degree, "dew" is deposited upon the surface of the cylinder. This difference of temperature corresponds to the difference of the vapor tension between the soap solution and water, and by means of a simple calculation we can thus determine the number of molecules in the solution which exert an osmotic action. This is, as we know, in normal crystoloid dissolve substances at least equal to that which results from the analytic concentration, while it is correspondingly greater in electrolytes with respect to the independence of the ions (amounting to as much as double in binary electrolytes).

When the osmotic concentration is found to be *less* than the analytical concentration, this indicates an association—a polymerization of dissolved molecules by means of which their osmotic action is correspondingly decreased or even imperceptible in the case of the coming together of too highly complex colloidal aggregate. For example, McBain and Salmon found the osmotic concentration of a 1-n-potassium stearate solution at 90° cent. to be only 0.42n. From their conductivity, however, it is possible to calculate with comparative accuracy only the concentration of potassium ions up to 0.41n: according to this, therefore, there can be present outside of the potassium ions, only very small quantities of osmotically active crystalloid dissolved constituents are present and both the bearers of the negative charge (*i.e.*, the potassium ions) and the undissociated salt molecules which are doubtless still present must exist in an osmotically inert colloidal form.

Thus McBain is compelled to form the conclusion that the simple anions of soaps in concentrated solution have, for the most part, collected themselves into colloidal aggregates which

*Translated for the *Scientific American Monthly* from *Die Naturwissenschaften* (Berlin) for Feb. 18, 1921.

he terms *ion-micellæ, each of which bears numerous negative charges.* Such highly charged particles are in the habit of annexing to themselves by means of electrostatic action water molecules and other neutral molecules, so that apparently the ion-micellæ of soap solutions contain a certain number of water molecules and salt molecules besides the polymarized fatty acid anions. As the degree of dilution increases the proportion of the colloidal constituent diminishes—it amounts, for example, to about 70 per cent in a 0.5-n-potassium stearate solution and in a 0.2-n-solution to about 30 per cent of the total concentration; it decreases in the same manner with a diminution in the homologous series, in which there may be observed a particularly wide gap between the C_{12} chain and C_{10} chain. In the concentrated solutions of the true soaps however, the positive potassium ions or sodium ions and the negative colloidal ion-micellæ may be regarded as the chief constituents. In the case of these multivalent ion-micellæ we must have them to possess great electrolytic mobility on account of their high charge. *This explains the extraordinary conductivity of these solutions* while their high content in colloidal constituents conditions their great viscosity. And the variability of both these properties in accordance with the degree of concentration and with the temperature follows inevitably from this new concept—in other words, the augmentation of the equivalent conductivity with an increase of concentration is to be explained by the increase in formation of the admirably conducted ion-micellæ.

The other peculiarities of soap solutions by which they are also differentiated from the alkali salts of the lower fatty acid, apparently depend likewise upon the content of ion-micellæ; these other properties include their uncommonly low density, their low superficial tension with respect to air and especially with respect to fatty oils and solid substances together with their detergent power. Finally, this new concept is not only of great importance with respect to the explanation of the essential nature of soap solutions, but it is undoubtedly destined to be of great service in the investigation of the many other so-called "colloidal electrolytes," such as those, for example, which exert functions of the utmost importance in the living organism.

Warming Buildings with Refrigerating Plants*

How Our Vast Natural Supply of Low Temperature May Be Utilized—A Parallel in Hydraulics

By Robertson Matthews

Department of Power Engineering, Cornell University

AT last we are showing interest in the conservation of fuel. This agitation really means that we are growing anxious about our supply of high-temperature heat—that heat of high elevation (of temperature) which, like the water of Niagara, will of itself, because of its high elevation, flow to regions of lower elevation, and which, through the agency of engines, can be made to do for us useful work.

In the production of power that heat only is useful which has a higher elevation of temperature than the atmosphere. The laws of the expansion of gases and vapors make imperative the need of such high-temperature heat. But when heat is required to warm buildings, high-temperature heat, to the extent now used, is not an absolute essential.

Consider atmosphere at freezing temperature entering a building. The heat in that atmosphere needs be raised in temperature only 38 deg. F. (that is up to 70 deg. F.) in order to satisfy ordinary room-temperature requirements. Why should we, then, have to use gases at a temperature over 2,000 deg. F. in order to raise the atmosphere through that small range of 28 deg. F.? Even the use for warming purposes of steam at 212 deg. F. means a misuse of high-temperature heat and of heat that costs money. Science proclaims the wisdom of using low-temperature heat for warming purposes.

In the myriads of tons of atmosphere and water on or surrounding this earth there is already stored an enormous quantity of heat—heat that keeps the air and water in their fluid state and at those temperatures which, compared with furnace and oil-engine temperatures, are never greatly below desired room temperature. But this heat is not available inside our dwellings in cold weather because heat, like water, will not, unaided, run up hill. Yet that air and water is a storehouse of heat—of low temperature heat—which but needs the provision of machinery and of effort to elevate it for use to that level (of temperature) at which we desire it.

The process of elevating this low-temperature heat, however, involves two considerations: (1) The means wherewith it can be done; (2) the commercial practicability. This commercial consideration calls for numerical values showing what the saving of high-temperature heat might be. As a start our scheme will be this: By the use of a small quantity of high-temperature heat to make available for warming purposes a much larger quantity of low-temperature heat.

*From *Power*, April 10, 1921.

Before we undertake, however, to consider what would be necessary in order to make low-temperature heat from the atmosphere available for warming buildings, let us get in mind some useful relationships by first seeing under what conditions an abundant supply of low-level water may be made available through the use of a lesser quantity of high-level water.

In Fig. 1 let the lake contain for our needs an unlimited quantity of water, ten feet below the level of the gardens, and therefore at present not available for irrigating them. Above, however, is a plateau where 1,000 cu. yd. of water can be accumulated in a pond, and from a height of 100 ft. supplied to the garden lands. But we need much more water than this 1,000 cu.yd. so let us run a turbine with the water from the pond, the turbine shall drive a pump, and the pump shall raise water from the lake to the gardens.

Will such a plan supply sufficient water? The calculations are simple. We know that a small weight moving through a long distance at the end of a lever, will raise one wheel of an automobile through a short distance. The conditions of pumping in Fig. 1 are comparable to that. With an ideal water turbine and an ideal pump—no mechanical or fluid friction whatever—we may put the work done by the pump as equal to the work obtained from the water turbine. And since the density of the water may be considered as practically the same in both pond and lake, the volumes of water will be respectively proportional to their weights. Then to get the cubic yards of water that it will be theoretically possible to pump from the lake, we may equate, 1,000 cu. yd. $\times$ 100 ft. = cubic yards of water pumped from the lake $\times$ 10 ft. This gives $\frac{1{,}000 \times 100}{10} = 10{,}00$ 0cu. yd. of water pumped from the lake to the gardens when using ideal machinery.

If we take actual machinery and allow one-half of the energy in the falling water to be consumed by the various quantities of friction, then the useful elevation or head of water would be only 50 ft. Hence only 5,000 cu.yd. of water would actually be pumped from the lake to the garden lands. But this would be five times the amount of water used to run the pump. This is somewhat of a gain in available water for the gardens, but even this is not all. For the water that passes through the turbine can be discharged upon the gardens, making a total of 6,000 cu.yd. of water actually made avail-

able. And it was made available not alone because there was water in the pond, but because we recognized the 100-ft. elevation or head that could be utilized to do work.

This illustration may seem far afield from the problem of warming a building, but it illustrates the fact that in order to make our great supplies of water, power or heat available, we must take into account in some form or other what is termed the elevation, or "head."

Today in order to have a desired amount of heat in the water or in the air flowing through the heating system of a building, we use the heat in fuel in much the same way as though it were the water in the pond of Fig. 1 and that it alone were desired at the level of the gardens. In short, we burn fuel, obtain intensely hot gases, then let the heat in these gases flow down hill (a temperature hill in this case) into the air or water which is to convey the heat of the fuel to the remote parts of the building. In so doing, we make available for heating the building even less heat than is in the fuel because part of the heat is lost in the cinders and up the chimney. This is much the same as if in our attempt to let the water from the pond in Fig. 1 flow down on the gardens there were a leak in the pipe or a break in the ditch which would let part of the water from the pond escape. Now, to get upon the gardens even less water than was in the pond is somewhat in contrast with obtaining six times as much water as was in the pond, which we found could be obtained by taking into account the work that could be realized from the falling water. Yet in heating our buildings today, we must have just such an example of waste.

PRESENT HEATING SYSTEM UNSCIENTIFIC

Our present system of heating buildings, it may now be stated, is unscientific in that it does not take into account the amount of work that could be done by the heat of the furnace gases nor—what means even more to us—the amount of heat that could be "pumped up" from below room temperature to a temperature somewhat above that desired in the building by utilizing this work. We attempt at present to utilize the heat in the gases to heat buildings without giving that heat a chance to do work; we simply let the heat run down hill and fail to take advantage of the excellent elevation of temperature that exists. Now the amount of high-temperature heat at our disposal is limited—it depends on our fuel supply—but the amount of low-temperature heat in the air and water around or on this earth is unlimited. Whether heat for warming buildings shall be scarce or plentiful depends on the progress of science and engineering.

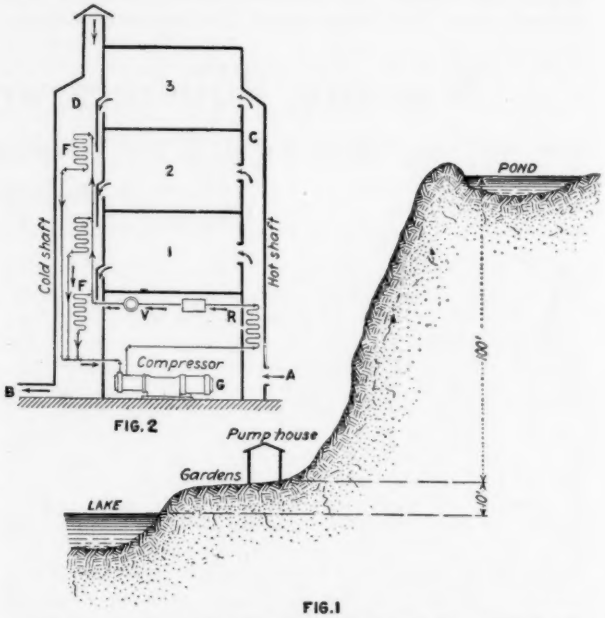
It is now over sixty years since Lord Kelvin proved that the systems used for warming buildings were prodigal of heat. The cheapness of existing appliances for warming buildings was, of course, then as now the deciding consideration. Since that day we have, however, not only improved our heating systems, but have made more marvelous strides in the efficient use of heat in heat engines. At that time oil and gas engines were still in the experimental stage. Today they are the most economical heat users that engineering has so far provided for delivering power, and because of this advance former scientific proposals are now in a fairer way to become commercial realities. We are turning today to mechanical means; that is, by the use of refrigerating machines, to cool our large hotels and auditoriums. That these same heat pumps, for that is what refrigerating machines are, could, if made to withstand a higher pressure, be used for heating our hotels and large dwellings, is not common knowledge. It was Lord Kelvin who first explained that this is the scientific way to heat buildings.

"PUMPING UP" LOW TEMPERATURE HEAT

In Fig. 1 it is shown that an abundance of water was made available by recognizing the possibilities of the 100 ft. head and its application to do work and to operate a pump. Furthermore, the quantities of heat about us which are necessary to keep the tons of air and water in their fluid state and at a temperature not greatly below that which we commonly desire in our homes have already been referred to. The problem, then, becomes one of applying energy and machinery to this great store of low-temperature heat and "pumping it up" to that level at which we desire it. The "head" to be pumped against in this case, is not one of feet of elevation, as when pumping water, but a "head" in degrees of temperature, measured with a thermometer.

But how can we pump heat? Easily enough. We handle heat by applying the same idea that we use in elevating coal, grain or crushed stone: we use a conveyor and handle the heat fast enough to prevent appreciable leakage. The most evident heat conveyors that we are all acquainted with are the air and the water of heating systems for buildings. Our choice here as the conveyor will, however, be ammonia.

Of mechanical apparatus we should have two pieces similar in purpose to those we had in Fig. 1: (1) A turbine or engine



FIGS. 1 AND 2. DIAGRAMS ILLUSTRATING NOVEL USE OF HYDRAULIC HEAD AND ANALOGOUS USE OF THERMAL HEAD FOR WARMING BUILDINGS

to utilize high-temperature heat; (2) a pump to elevate low-temperature heat. And just as we used water to pump water, we can likewise use heat to pump heat, but because we are pumping heat, a somewhat unfamiliar process, we must not let the greater magnitude of heat discharged by the pump over that supplied to run the pump—which conditions our problem will finally show—mislead us into thinking we are attempting the unreasonable. The heat discharged is a measure of the capacity of the heat pump, and the capacity of a heat pump to pump heat must not be confused with heat-engine efficiency in the use of heat.

Those buildings that are equipped with refrigerating machines have already both the required "turbine" and the "heat pump." For, as stated before, the refrigerating machine is a heat pump. But while the "turbine" (engine) could probably meet the necessary load without requiring much change, the "pump" (compressor) might not be capable of safely carrying the necessary pressure. We shall, however, since heat pumps are as yet too costly to be installed for cold-weather use only, assume that a refrigerating machine is already installed for summer use, which is strong enough for the pressures required when the machine is turned over to serve as a warming device in cool weather.

In Fig. 2 a section of a building of several stories is shown

diagrammatically. Refinements of design and equipment will not be considered. The purpose will be to show how practicable the heat pump may be, under some conditions, for warming a building. Considering first the path of the air. Fresh air enters the duct *A* and is heated by coils *E*. The warm air rises in the shaft *C* and enters rooms 1, 2, 3, through the ducts shown. The spent air from the rooms then passes through the ducts provided into air shaft *D*, where it mingles with a stream of atmospheric air that also enters through a suitable duct. In shaft *D* are other coils *F* colder than the mixture of spent air and atmosphere, so that owing to their cooling effect it will, acting as a reversed chimney, serve the double purpose of helping to withdraw the spent air from the rooms and of providing a flow of air across the coils *F* whose function is to absorb low-temperature heat from that air.

Consider next the mechanical operation of the heat pump. Liquid ammonia discharged from the receiver *R* through the expansion valve *V* becomes in part a gas and suffers a drop in temperature. In the coils *F* the cold mixture of liquid and gaseous ammonia takes in heat from the air in the air shaft *D*, and the ammonia may become wholly gasified. Next, the compressor *G* draws in a cylinderful of the ammonia gas and compresses it. But the work of compressing the gas raises its temperature, and we compress it enough to get the

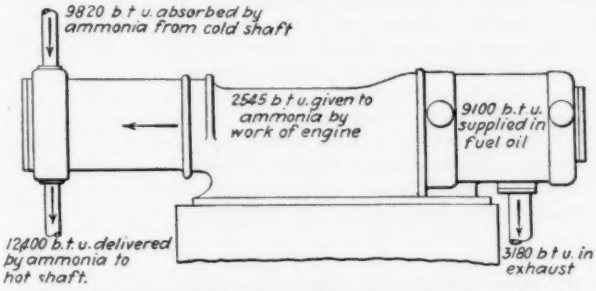

9820 b t u. absorbed by ammonia from cold shaft
2545 b t u. given to ammonia by work of engine
9100 b.t.u. supplied in fuel oil
12400 b.t.u. delivered by ammonia to hot shaft.
3180 b t u. in exhaust

FIG. 3. DIAGRAMMATIC ILLUSTRATION OF HEAT UNIT TRANSFERENCE BY AMMONIA COMPRESSOR

temperature desired in the coils *E*, which in turn give up the high-temperature heat of the ammonia to the fresh air entering the shaft *C* by way of the duct *A*, and this chills the ammonia, which condenses and returns to the receiver *R* as a liquid. For simplicity, the double system of coils by which, for the sake of safety, the ammonia would be made first to heat water, which in turn would heat the air, is not shown, nor is any system of radiators which could take the place of the heating done upon the air in shaft *C*.

MINOR HEAT LEAKAGES IGNORED

Coming next to the path of the heat we ignore minor heat leakages. Low-temperature heat in the cold-air shaft *D* is picked up by the cold ammonia (the conveyor) and is carried over to air shaft *C* with the progress of the ammonia. On the way over, however, the quantity of heat in the ammonia is increased, for the compressor does work upon it, and just as a gas or a vapor, when it expands behind a piston, converts into work some of the heat it contains, the reverse, or a conversion of work into heat, which heat goes to increase the heat already in the ammonia, takes place when compression occurs. On the way over, then, the compressor increases the pressure, the temperature and the heat content of the ammonia, and the amount of heat thus added to the ammonia will be the equivalent of the foot-pounds of work that the engine delivers to the compressor end of the machine. If, then, we let *Q* stand for "quantity of heat," we shall have, when the ammonia arrives in the hot coils, an amount of heat available for discharge to the fresh air of shaft *C* equal to the *Q* absorbed in shaft *D* plus the *Q* added by the work of the compressor. This is comparable to the operation in Fig. 1, where the water drawn up from the lake plus the water fed to the turbine become as a combined quantity available for watering the gardens.

The compressor has now accomplished two things—it has increased by a definite amount the heat in the ammonia over the amount that was absorbed from the cold air, and it has raised the pressure and temperature of the ammonia till, as a result, it is possible for both that *Q* obtained from the cold air and that *Q* added in the compressor to flow into the warm air shaft. This is a most happy result for our undertaking. The proof that this result is possible requires the use of diagrams which will not be introduced here. Let it suffice, therefore, to recall the results in Fig. 1, where the lake water plus the water that does the work are eventually combined and discharged upon the land. Reviewing the path of the heat, low-temperature heat is absorbed in shaft *D*, this heat, while being conveyed across to shaft *C*, is increased and also raised in temperature by the compressor; then what has now become high-temperature heat is discharged into shaft *C*. The ammonia is condensed and returns by way of the receiver and expansion valve to repeat its conveying functions.

What, now, is the magnitude of the amount of heat given to the air in shaft *C* compared with the heat supplied to make that warming possible? This will be shown later. For the present assume the compressor is driven by an oil engine (see Fig. 3). If, now, in our chosen installation the number of heat units in the fuel oil supplied to the engine—in order that the engine may impart to the compressor work enough to compress the ammonia—be less than the amount of heat discharged to the fresh air in shaft *C*, then we shall have a system that discharges more heat than we put into it. This is something a house furnace cannot do.

PERPETUAL MOTION NOT ATTEMPTED

Going back to the problem of getting water upon the gardens, perpetual motion was not obtained when more water was delivered upon the gardens than was used to pump that water, nor was any attempt made to get the water fed to the turbine to return to the pond. To have tried to do so would have been an attempt at perpetual motion. What was really done was to take a small quantity of water from the pond, let it do work and then allow it to remain at a greatly lower level. The same reasoning applies to our use of heat in the heat pump; we have gained in the quantity of heat at our disposal for heating purposes, but have sacrificed, for part of that heat, an enormous elevation of temperature. We have raised some heat from perhaps 35 deg. to 125 deg. fahr., but have also let down other heat in the cylinder of the oil engine from perhaps 2,500 deg. to 900 deg. fahr.

Because the heat pump involves a "conveyor" (the ammonia) the operations are not so direct as with the water turbine and its pump. For example, in the water turbine all the water supplied to it goes to join the water pumped; in the heat turbine (the oil engine) all the heat supplied to it does not go to join the heat "pumped up," but owing to the limitations of heat engines most of the heat in the fuel supplied to the engine goes finally out in the exhaust and jacket water. In our job, however, much of this "waste heat" could be used in air shaft *C* to help boost the temperature. Were the heat engine as efficient in converting potential energy into work as is the water turbine, our problem would work out much better than it does.

A SPECIFIC PROBLEM EXPLAINED

Our undertaking has now narrowed down to running the ammonia compressor at a high enough discharge pressure to give condensing water sufficiently hot to warm the fresh-air supply. It remains to show by calculation whether it would be more profitable from the point of view of heat economy to operate the refrigerating machine instead of a boiler or furnace in order to warm the building in cool weather.

Let us consider first a cool, rather than a cold-weather problem; the atmosphere to be not below 40 deg. fahr., and that the mixture of spent and fresh air will leave the shaft *D* at a temperature not below 35 deg. fahr. We shall assume the following data and conditions: For simplicity in calculations we shall let the oil engine deliver to the compressor one horsepower-hour, or the equivalent in work of 2,545 B.t.u. per hour.

We shall ignore jacket effect for the compressor and consider no pre-cooling of the ammonia. These are two conditions unfavorable to our problem.

We shall, further, ignore the heat leakage in connections between pieces of apparatus and shall assume the ammonia enters the compressor in dry saturated state.

Heat value of fuel oil, 18,200 B.t.u. per pound.

Fuel consumption of oil engine per brake horsepower-hour, 0.5 lb.

Suction pressure in ammonia compressor, 53 lb. absolute; corresponding temperature in cold oils, 25 deg. fahr.

Discharge pressure in ammonia compressor, 312 lb. absolute; corresponding saturation temperature in hot coils (condenser), 125 deg. fahr.

We desire to find the ratio of the heat supplied by the heat pump to the heat supplied by a boiler and furnace. The same amount of fuel oil to be used in both cases, and the heat to be delivered to the hot coils in shaft *C*.

Referring to Fig. 3, the engine is supplied with $0.5 \times 18{,}200$, or 9,100 B.t.u. per brake horsepower-hour. Of these 9,100 B.t.u., say 35 per cent or 3,180 B.t.u., go out in the exhaust. This "waste heat" could be utilized to heat air in shaft *C*. Other 2,545 B.t.u., the equivalent of one horsepower-hour, go to do work at the compressor and upon the ammonia. These 2,545 B.t.u., together with the B.t.u. absorbed from the cold coils will give the number of B.t.u. supplied to the hot coils by the heat pump when 0.5 lb. of fuel oil is used.

But how many B.t.u. are absorbed from the cold coils when 2,545 B.t.u. are supplied as work done on the ammonia? For the answer we must refer to tables and chart of ammonia properties (see "Mark's Hand-book," pages 333 to 335).

From the hand-book we find that (per pound of ammonia circulated) the amount of heat absorbed from the cold coils in shaft *D* will, for the conditions chosen, be 436 B.t.u. We further find that the amount of work done on one pound of ammonia while passing through the compressor will be equivalent to 113 B.t.u. Now these two quantities combined, or 549 B.t.u., is the amount of heat supplied to the hot coils for every pound of ammonia circulated. Hence, if 549 B.t.u. are discharged into the hot coils every time that 113 B.t.u. are added to the ammonia because of the work done on it in the compressor, it follows that the number of B.t.u. discharged into the hot coils when 2,545 B.t.u. are supplied as work upon the ammonia, will be $2{,}545 \times \frac{549}{113} = 12{,}400$ B.t.u. Using the same quantity of oil under a boiler and allowing a boiler and furnace efficiency of 75 per cent, the heat that could be supplied to the coils in shaft *C* would be $0.5 \times 18{,}200 \times 0.75 = 6{,}820$ B.t.u.

From these values we get the ratio of heat supplied by heat pump to heat supplied by boiler and furnace as $\frac{12{,}400}{6{,}820} = 1.82$. With the heat of the exhaust fully utilized, the ratio becomes $\frac{15{,}580}{6{,}820} = 2.28$.

Were it necessary to have the suction temperature zero deg. fahr., then the heat pump would deliver but 9,750 B.t.u. when 0.5 lb. of fuel oil was supplied, and the ratio becomes only 1.43. In this case, however, a large amount of precooling could be obtained, which would boost the value of the ratio, as would also the jacket effect, which would be essential here in order to keep down an extreme amount of superheat. Further, we might have to resort to mechanical means for defrosting the coils in shaft *D*.

The commercially permissible operating conditions depend, of course, on the price of fuel, since that together with the hours of operation determine the allowable investment in heating surfaces. The ideal condition would seemingly be to make ice while pumping heat, but the output of ice would probably be too vast for storage capacity.

With the compressor driven by electric motor and with the compressor piston receiving 68 per cent of the energy supplied to the motor, the heat pump would deliver, under conditions of the original problem, 11,330 B.t.u. to the coils per kilowatt-hour supplied to the motor. One kilowatt-hour converted directly into heat would give but 3,412 B.t.u. Dividing 11,330 by 3,412 gives a ratio of 3.32. This value, of course, takes into account no steam-electric plant losses and is worth considering only with hydroelectric power.

The manner in which the improvement in oil-engine economy advances the possibilities of the heat pump can be shown if we assume that for a steam-driven heat pump three pounds of coal with 13,200 B.t.u. per pound, would be needed per brake horsepower-hour of engine. These three pounds of coal burned under a boiler, with a boiler and grate efficiency of 65 per cent could deliver to the coils $3 \times 13{,}200 \times 0.65 = 25{,}700$ B.t.u. Now for the conditions of the original problem, 12,400 B.t.u. are delivered by the heat pump per brake horsepower-hour supplied. This gives a ratio of $12{,}400 \div 25{,}700 = 0.48$ only. Were the heat pump steam-driven, the steam might better be used direct from boiler to coils.

The temperature of 125 deg. fahr. selected for the hot coils would call for the use of extensive heating surface. Higher temperatures are obtainable, of course, if we submit to the increasingly higher pressures and to the smaller ratio which corresponds with an increase in the work required. Without tabulating more values of the ratio, it may be stated that the work required increases at a slightly diminishing rate as higher temperatures in the hot coil are selected.

HOW TO WELD CAST IRON ELECTRICALLY

THE difficulty in welding cast iron with the electric arc is not encountered because the metal cannot be properly fused, but is due to the fact that the sudden intense heat of the arc over a local area results in the production of a hard weld and the introduction of contraction stresses which often result in cracking. Using the carbon welding process, cast iron welding rods may be fused into a cast iron piece. Using the metal electrode process and a soft iron or steel electrode, it is impossible to make a reliable weld between the added material and the cast iron. Using the metal electrode process certain work can be done by the introduction of steel studs in the cast iron pieces to be welded together so that a certain amount of strength is obtained by the bond formed between the steel studs by the welded material. For welding small gray iron castings a 3/16-inch cast-iron welding rod and 300 amperes welding capacity are required. A small gray iron casting should be broken and the edges beveled, using the carbon arc for cutting. The pieces should then be placed in a carbon mold so that the molten iron when it is added will not run away from the joint. The carbon arc should be used to preheat the casting. It is not necessary to heat the pieces to a red heat. The carbon arc and cast iron welding rod should then be used to fuse the added material to the piece. Care should be exercised not to play the arc upon the weld any longer than is necessary to give complete fusion. In case the metal gets too hot and runs badly the arc must be broken, and an interval of time allowed for it to cool slightly to eliminate the trouble. After the weld is completed the piece should be wrapped securely in asbestos paper and allowed to cool slowly for six or eight hours; larger pieces require as long as 24 hours to cool.

As an alternative to wrapping in asbestos paper the piece may be covered in previously heated slacked lime.—*Foundry*, January 15, 1921, p. 68.

Blast Furnace Flue Dust Recovery*

A Direct Process of Wet Recovery Which Avoids the Necessity for Sintering or Briquetting

By George B. Cramp

WITH a plentiful water supply available, other considerations in connection with the installation of a wet washing system for cleaning blast furnace gas, and incidentally a flue dust recovery system are:

1. Dry dust catchers for receiving and holding the heavier dust particles such as are carried from the blast furnace by the gas under normal working conditions, and also the bulkier coke, ore and limestone stock thrown from the furnace during a slip.

2. Wet gas washers or scrubbers for washing out of the gas all dust remaining therein after having passed through the dry dust catcher.

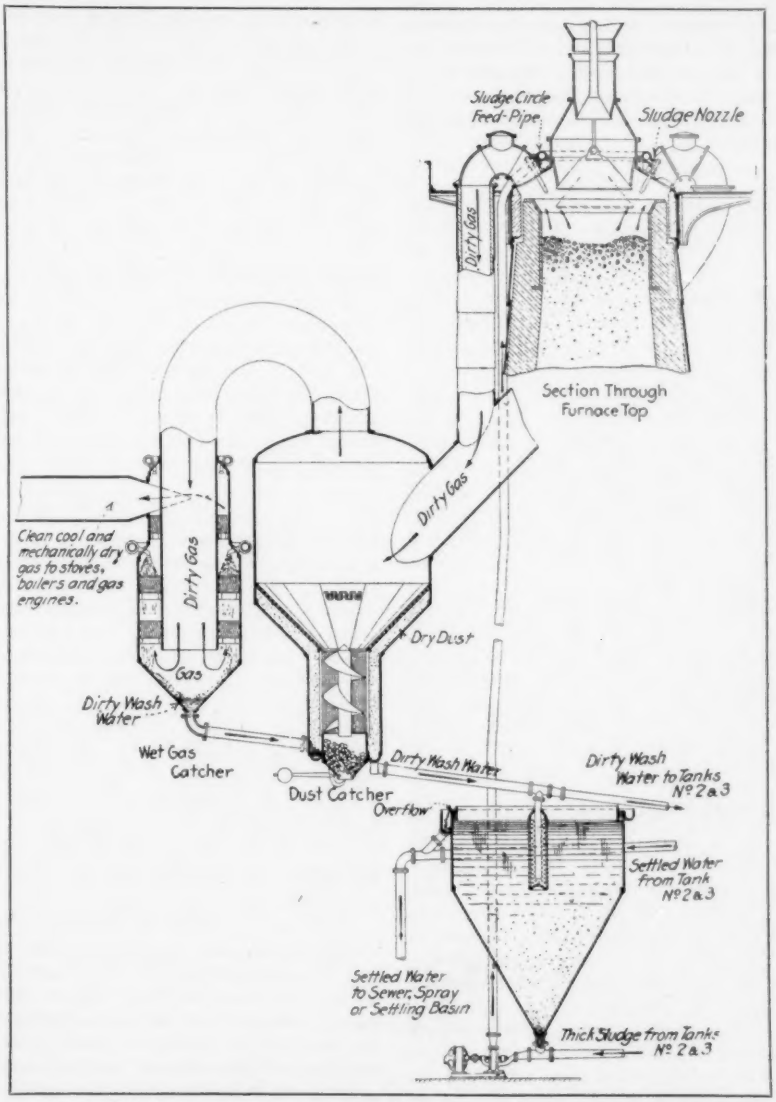
3. Disposal of the dirty wash water from the gas washers or other apparatus in which the water has been used in any manner to wash dust from the gas.

4. Recovery and treatment of the wet dust from the wash water, along with the flue dust recovered in a dry state from the dry dust catchers.

5. Method to be used in recharging the recovered flue dust into the blast furnace.

The foregoing considerations will be taken up in order with a view to outlining present practice, pointing out imperfections and suggesting improvements, and with the further object of accomplishing a coordinated arrangement of improved apparatus which will satisfactorily and effectively recover and recharge into each particular furnace practically all flue dust produced by that furnace, at the furnace site, and will accomplish this direct recovery of flue dust automatically, continuously and without labor or transportation cost, and with a minimum water and power requirement.

Though practice at various blast furnace plants differs as to the number and size of the dry dust catchers used, there is but slight difference in their design. They are usually of cylindrical shape with inverted conical bottom which forms a hopper for the dust and larger stock deposited. The top is usually dome shape or conical, and the downcomer or downcomers which conduct the gas from the top of the blast furnace, enter through the top or the side of the dust catcher. The gas outlet connection may occur at either place, but preferably opposite, or as far from the inlet or downcomer connection as possible. There is but little advantage gained by either arrangement, however, as the amount of dust precipitated in the dust catcher varies in accordance with the velocity and dust content of the gas passing through it, and the larger the dust catcher the lower the velocity of the gas moving through it and the greater the dust precipitation therein.


Sludge Circle Feed-Pipe
Sludge Nozzle
Dirty Gas
Section Through Furnace Top
Dirty Gas
Clean cool and mechanically dry gas to stoves, boilers and gas engines.
Dirty Gas
Gas
Dry Dust
Dirty Wash Water
Wet Gas Catcher
Dirty Wash Water
Dirty Wash Water to Tanks Nº 2 & 3
Dust Catcher
Overflow
Settled Water from Tank Nº 2 & 3
Settled Water to Sewer, Spray or Settling Basin
Thick Sludge from Tanks Nº 2 & 3

DIAGRAMATIC VIEW OF NEW PROCESS OF RECOVERING FLUE DUST

The dust is separated from larger particles and flushed out; then sludge is pumped directly into top of furnace

Not much has been done toward accomplishing anything within the dust catcher other than what has just been related; but the dry dust catcher offers great possibilities in the economic handling of flue dust if designed as a separator for separating flue dust from the larger coke, ore and limestone stock discharged from the furnace during a slip. Separation of these grades would permit the fine dust to be sluiced or flushed out of the separator with the same water that is previously used to wash the gas in the wet gas washer, thus combining all flue dust and necessitating but one method of handling thereafter. The larger stock brought down within the separator is freed from dust and held within the separator until drawn off into cars, and taken to the ore or coke bins to be recharged into the furnace.

The improvements in dust catcher design just proposed are met in the design shown in the drawing. The first and greatest saving in cost of handling flue dust and recovery of

*From the *Iron Age* March 24, 1921.

bulkier stock is possible of realization in this improved design, which may be termed the most vital of any of the improvements proposed, as it pre-determines the extremely simple methods of handling the flue dust in wet form made possible by the separating and dust flushing features of the design.

DUST PRECIPITATION IN INSTALLMENTS

At some plants further efforts are made to precipitate dust in the dry state, between the dry dust catcher and the wet gas washers, by installations of secondary dust catchers, dust legs or pockets and dry whirlers; all of which catch some dust as the gas passes through them. This would occur, however, if an almost infinite number of pieces of apparatus were used to recover the dust in a dry state, and it is for this reason that recent practice has inclined toward the omission of all dry dust catching devices between the first dry dust catcher and the wet gas washer, and installing the gas washer as close to the dust catcher as possible, so that the connecting gas main may be shortened to the minimum and otherwise arranged to be self-cleaning, in that no dust will find a lodging place throughout its length.

TYPES OF GAS WASHER DESIGN

Wet gas washer design has in the past covered widely different views on various types of apparatus for accomplishing the washing of dust from blast furnace gas, using water as the washing medium. All these types of washers may be roughly arranged into two groups: power-driven and stationary washers. Of the power-driven washers the Thiessein is a good example, and is one of the few designs of power-driven washers remaining in practical use; and this for secondary or final washing only, it being entirely out of consideration as a primary washer or scrubber.

In the stationary group of washers the rain or spray type, and the baffle types, form two subdivisions. By rain or spray type is meant those washers or scrubbers, as they are more often called, wherein a rain or spray of water is dropped from a considerable height withn a tower through which the gas travels upward, the dust carried by the gas being washed out by contact with the spray of water.

Within the baffle type washers sprays of water are directed on baffles made of wood or metal, the surfaces of which serve to retard the water as it falls from top to bottom of the scrubber. The baffles are so arranged that they split up the gas body as it travels upward through the scrubber and thus cause the gas to come into more intimate and positive contact with the wet surfaces of the baffles, on which much of the dust impinges and is then washed off by the continuous spray of water directed on them.

Of the two types of stationary washers just described, the baffle type has proved to be of greater efficiency for two reasons. In the rain or spray type scrubber there are usually heavier sprays of water required to break up the gas body and penetrate it. Gas in moving through a spray acts much like wind with rain in a storm, a strong wind often being seen to blow sheets of rain at a sharp angle to the perpendicular. Gas acts likewise in a spray type scrubber, except that, being confined within the scrubber, the gas tends to travel through the spray. In a well arranged baffle scrubber, on the other hand, channeling is practically eliminated, as the gas is split up into thin bodies which are compelled to travel between two wet walls which prevent their surging or channeling. A further advantage is gained by the baffles in that they retard the fall of water, thus bringing a given quantity of water into longer contact with the gas, and causing it thereby to wash out more dust from the gas.

ACTION OF THE BAFFLES

The nature and position of baffles within a gas scrubber are determined by simple considerations. If a wet board or sheet of metal one foot square is projected into a moving body of dirty gas, with its greatest area at right angles to the direction the gas is moving, it will be found to pick up no more dust from the dirty gas than if turned ninety degrees to the original position, while the resistance to the moving body of gas, with the baffles in the first position, would be much greater. It is for this reason that baffles are set edgewise or parallel to the direction of gas flow.

After exposure of one square foot of wet baffle surface to a body of dirty gas in the manner just described, it will be found to have collected a certain amount of dust in a given length of time. If twice the area of baffle surface is exposed to the dirty gas about double the amount of dust will be collected, and by provision of ample baffle surface a given volume of gas, of given dust content, is continuously cleaned or washed of dust by the action of the water spray directed on the baffles.

In the selection of materials for baffles, wood is usually chosen, mainly because it is a cheaper material and because it can be readily built into the scrubber. Wooden baffles, however, have some serious disadvantages. One of these is their bulk. They are usually about an inch thick, and as the spaces between baffles cannot be much less than an inch, because of the tendency to warp and thus close the openings between them, it is readily seen that baffles of wood occupy one-half of the cross sectional area of the scrubber in which they are placed. On this account a scrubber shell is necessary of twice the area that would be required if thin plates or sheets not over 1/32 in. thick were used. This is a very serious consideration when arranging spray water distribution, as the area over which a given quantity of water is to be sprayed is about twice as great with wooden baffles as would be required with thin sheet baffles.

A further objection to wooden baffles is their liability to being over dried and warped if the water should go off the scrubber while in operation, while at least one instance is known where the baffles have taken fire during construction, causing the scrubber shell to buckle badly.

DRYING THE SCRUBBED GAS

After having been washed by contact with wet baffles and spray, the gas has been cooled and cleaned of practically all dust. But on leaving the scrubber it carries with it considerable entrained moisture in the form of fine water mist, which has been picked up and carried along by the gas as it moves out of the scrubber at high velocity. It is, therefore, very desirable to remove this moisture, if possible, within the scrubber, and much of it may be removed by causing the gas to impinge on baffle surfaces not sprayed constantly with water. The moisture in the gas coming in contact with the baffle surfaces gathers on them, and forming in drops, trickles down and off the baffles. For removal of moisture from gas in this manner the wooden baffle is not well suited because of its bulk, and as considerable drying area is necessary, it would be impractical to consider this construction within a scrubber.

DISPOSAL OF WASHER WATER

Probably as great a problem as that of gas washing itself is met with in considering proper methods for the disposal of dirty water from the gas washer. Government restrictions have in the past, and will in the future, make it more imperative that water which has been used in blast furnace gas washers be first settled in properly constructed tanks, basins, or ponds of sufficient size to accomplish the retention of most of the dirt from the water before it is turned into public watercourses, where it rapidly clogs or obstructs the channels, the yearly deposits from one furnace alone being enormous.

From an economic viewpoint it is even more important that the gas washer water should be made to yield up its valuable burden of latent raw material. Several different designs of settling basins are in use, in most cases it being the practice to divert the water from all scrubbers to one basin. For this reason the basin must be of such large dimensions as to necessitate its being located some distance from the furnaces or scrubbers.

The basin may be of single compartment construction or, more usually, of two or more compartments, which permit of one being cleaned of the deposited flue dust sludge while the dirty wash water flows through the other. Cleaning or dredging is done with a locomotive, or overhead electric crane. A more recently developed design of settling basin provides settlement and cleaning continuously in one circular basin, the cleaning being accomplished by use of a bottom scraper or plow mechanism which works the sludge toward the center of the basin, from which point it is then pumped.

At plants where it is the practice to recharge the wet sludge into the furnace, it would be a decided advantage to settle the dirty wash water in two or three tanks, the diameters of which need not be over twenty-two feet with a depth of ten feet. Settling tanks of this size could, in most plants, be located near the furnace. The tanks should be of deep conical bottom construction, in which sludge could settle to considerable depth, for the greater the depth attained the more dense and less watery the sludge becomes. With this arrangement sludge at almost any desired consistency could be tapped off at the bottom of the tank and charged as desired.

HANDLING THE ENTRAINED DUST

Where it is regular practice to charge into the furnace all flue dust recovered in the wet form, and where it would be desirable to charge in the wet state all dust produced, the problem is further complicated because of the dust recovered dry, which amounts to more than that recovered wet. Dry dust at some plants, and both wet and dry dust at others, is transported to a sintering or briqueting plant, and after treatment, is returned to the furnace and charged in the usual way. Consideration of the sintering or briqueting processes for treatment of flue dust is obviated, however, if the dust is all combined and brought down in the wet form as suggested above, which leaves for consideration only the method of charging the flue dust into the furnace.

Where flue dust is treated by either the sintering or briqueting process, the method of charging is simple. The product is dumped into the stock bins at the furnace, charged into the stock larry car and thence into the skip car, as is all the coke, ore and limestone charged into the furnace.

OBJECTIONS TO CHARGING WET FLUE DUST

Where all flue dust is to be brought down in the wet form, however, the method of charging is a matter of serious consideration. It has already been stated that at some plants wet flue dust is charged directly into the blast furnace without being either sintered or briqueted. This practice is not accomplished without considerable cost of handling and other inconvenience, and thus far no standardized system of handling or charging seems to have been developed.

At some plants both dry dust and all ore charged into the furnace are wet down with water just after being dumped into the skip car and before it is hoisted to the top of the furnace. An objection is always raised to this practice, however, because of the fouling effects of wet stock in the skip car and on the charging mechanism; but where the recovery of all flue dust in wet form is accomplished as previously suggested, the charging of wet sludge is greatly simplified by application of the hydraulic system for lifting the wet sludge through a pipe to the top of the furnace, where it can be easily distributed within the furnace through a circle pipe and specally designed nozzles which pierce the top cone of the furnace and introduce the sludge without bringing it into contact with any of the charging mechanism.

SPECIAL DUST CATCHER DESIGN

The foregoing description of methods, practice and apparatus, with suggestions for improvement, is based on actual operation, recent development or experiment. The design of apparatus required to accomplish the suggested improvements, however, is represented in the accompanying drawing.

The dust catcher shown is of about the usual design, except that it has, about 18 inches above and inside its conical bottom, a false conical bottom of plates having ¼-inch slots so arranged as to allow all fine dust and particles smaller than ¼ inch to pass from the upper to the lower chamber, which chambers are formed by the false bottom. The dust after passing through the false bottom drops into the true bottom of the dust catcher, and slides thence into the dust flushing well, where it is flushed out by the dirty wash water from the gas washer.

Any particles brought down in the dust catcher that are too large to pass through the ¼-inch slots in the false bottom simply slide down the false bottom into the helical chute in the bottom center of the dust catcher-separator. This helical chute is encased in a cylindrical cage of bars with ¼-inch spaces between them. In ordinary operation this chute would not be required, but in cases of bad furnace slips, when tremendous quantities of coke, ore and limestone with much fine dust are suddenly thrown into the separator, much of the fine dust would remain unseparated except for the presence of the helical chute, down which all this stock must pass on being dropped out of the dust catcher-separator, into cars in which it is carried to the stock bins. The chute inclines all material rolling down it against the encaging bars and the fines, or particles smaller than ¼ inch sift out between the bars into the flushing well.

By this separation much valuable stock is immediately made available for recharging into the furnace, and without cost for screening or otherwise handling, except transportation to the stock bins. The fine dust separated within the separator is carried out of the flushing well by the water from the gas washer, thus eliminating all cost of handling and treating in the dry state.

After dropping much of the heavier dust in the separator, the gas passes through a self-cleaning gas main into the gas washer. It enters through the drop leg of this main, which drops vertically into the center of the washer. The purpose of this construction is to accomplish perfect gas distribution on entering the washer and drop a great part of the heavier dust—still carried by the gas—immediately into the bottom of the washer. A further object is to permit the washer to be used as a water seal gas valve. By this arrangement the transverse sectional area of the washer is lost to gas cleaning to the extent of the transverse sectional area of the gas main dropping through it, but the thin corrugated sheet metal baffles suggested occupy so little of the transverse sectional area of the washer, effective for gas washing, that the shell diameter of the washer may be even less than scrubbers in which wooden baffles are used. Furthermore, the area over which water spray must be distributed is so much less than that of larger diameters that a material increase in gas washing efficiency is obtained.

On entering the washer through the open end of the drop leg of the gas main, the gas turns an angle of 180 degrees and rises uniformly up through the torrent of falling water, and begins to pass through the lower set of baffles, which are of thin corrugated sheet metal and spaced about ¾ inch apart, being held thus by simple indentations of the corrugations which occur at odd points on the sheets.

CLEANSING EFFECT OF THE BAFFLES

In the lower baffles the gas is subjected to 80 square feet of cleaning surface for each square foot in the area of the entering pipe, using a standard 200 3-inch width of corrugated sheet. The gas is thereby cooled and cleaned of the heavier dust, which, combining with the water flowing down the surfaces of the baffles, is continuously washed into the bottom, and thence out of the gas washer.

Still rising upward, the gas passes through a second set of baffles similar in construction to those just described, but spaced ⅜ inch apart. In passing through these baffles it is subjected to 160 square feet of additional cleaning surface,

and is here thoroughly cleaned of dust and cooled to within a few degrees of the entering wash water.

The gas travels through these baffles at about half its velocity in the entering main, but above the continuous spray nozzles shown on the washer the shell is contracted to a smaller diameter, which increases the gas velocity to that in the entering main. As has already been described, this increased velocity of the gas causes more forceful impingement of the water mist it has picked up in the lower part of the washer, against the dry or unsprayed baffles set in this section of the washer. These baffles are spaced about 3/16 inch apart and the gas in passing through them is subjected to 320 square feet of drying surface. As the mist continues to impinge on the baffle surfaces it forms into drops and flows down their surfaces and into the lower part of the washer.

Cleaning, cooling and drying the gas of entrained moisture is in this manner accomplished in one piece of apparatus, thus providing gas which may be carried through comparatively small unlined mains to the stoves, boilers, or gas engines. The compact baffle arrangement permits the bottom of the washer to be raised to a level sufficiently high to allow the dirty wash water flowing from the washer to enter the dust catcher-separator, where it picks up additional dust, and goes thence to the settling tanks.

Dirty wash water carrying all dust brought down in the gas washer and dust catcher is thus run by gravity through straight pipes to the settling tanks, which for a modern furnace plant would be three in number, and about 22 feet in diameter, or 20 feet square, with a depth of about 10 feet on the sides, which would permit of their being located in most furnace plants in line with the dust catcher and beyond it. The water enters the tanks through a seal pipe, which prevents gas at all times from escaping from the dust catcher with the water. The water passes out into the tank through a perforated distributing pipe and thence travels at an ever decreasing rate to the side wall of the tank, where it overflows. In passing slowly through the tank, about 90 per cent of the flue dust in the water is precipitated and settles into the steep conical bottom of the tank in the form of a silt-like deposit or sludge. The water flowing over the weir wall of the tank drops into a trough running around the tank and thence flows through a pipe to the sewer, which may carry it to a nearby stream or settling basin, or to a spray pond if the same water is to be used over again.

As the sludge settles to the bottom of tank to increasing depths, water is to a great extent displaced by the pressure of the upper mass of material, so that at the bottom of the tank where it is removed through the sludge pipe the sludge would, under proper working conditions, contain not much in excess of 35 per cent water, which would permit of its being immediately charged into the furnace.

The nature and consistency of the recovered sludge make it possible to charge hydraulically with a high-head centrifugal sludge pump, with a power requirement of not more than 5 electrical horsepower running continuously.

CHARGING THE SLUDGE INTO THE FURNACE

The sludge is collected and pumped through comparatively large pipes to reduce abrasion. It enters the top of the furnace through a circle pipe and specially designed nozzles piercing the top cone of the furnace. The nozzle openings are flat and are of sufficient number to distribute uniformly a ring of sludge on to the stock just under the large bell. This sludge ring distributes itself over the stock and the new charges of stock are dropped in on the sludge layers. Excess moisture in the sludge is therefore rapidly absorbed by upper and lower stock layers, thus accomplishing a wetting down of all stock and lessening dust production.

ADVANTAGES OF PROPOSED SYSTEM

The advantages gained by this system are:

1. Separation of fine flue dust from the bulkier stock is immediately accomplished, and the large stock made available for charging into the furnace.

2. The fine flue dust is flushed out of the dust catcher-separator continuously by the same wash water that has previously been used for gas washing.

3. The gas is thoroughly cleaned, cooled and mechanically dried, and may be conducted through relatively small unlined mains to small-checker stoves, boilers, or gas engines.

4. The water used in the gas washer carries all dust from both washer and separator to the settling tanks, where all but about 10 per cent of the dust is recovered from the water in wet form, thus eliminating all cost of handling and treating contingent on recovery of dust in dry form, or when recovered part wet and part dry.

5. All dust recovered in wet form is immediately available for charging into the furnace, eliminating the necessity of treatment by either the briqueting or sintering process.

6. Flue dust in wet or sludge form may be pumped into the top of the furnace, accomplishing the wetting down of all stock and consequent retention of much of the dust that would otherwise be blown out of the furnace.

7. Recovery of flue dust is accomplished at each furnace, making possible the recharging of the same flue dust produced by that furnace.

8. The dirty gas washer water is sufficiently purified to permit of its being run into a public water-course.

9. Water, power, transportation, labor and operating costs for this recovery process are less than that of any other.

10. The first cost of constructing a direct recovery plant is negligible compared to that of plants for treatment of flue dust by any other process.

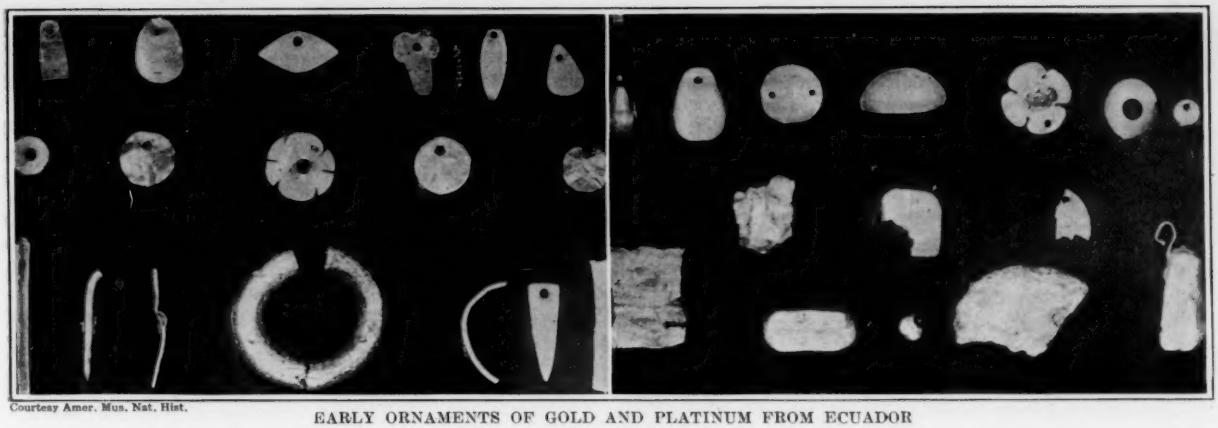
MOLYBDENUM STEELS

IN the March 2nd issue of *Chemical and Metallurgical Engineering* there appears an interesting discussion of molybdenum steels by Dr. John A. Matthews from which the following is quoted:

Molybdenum, particularly in conjunction with chromium, seems to confer the property of deep hardening. This is to be expected from the observation that molybdenum steels resist the drawing temperature to quite an unusual degree. In other words, they require a higher drawing temperature to reduce the physical properties by the same amount that they would be reduced in similar steels without the presence of molybdenum. This indicates that molybdenum tends to keep the carbon in steel in the combined or martensitic form, and when in that condition to retard its passage to the sorbitic or troostitic state. Some years ago the writer sent to Prof. H. C. H. Carpenter, then at the National Physical Laboratory of Great Britain, a chrome-molybdenum steel together with a variety of commercial high-speed steels for use in his investigations upon the drawing or softening of hardened high-speed steels. This particular steel contained but 4 per cent of molybdenum, 3 per cent of chromium, and about 0.47 per cent carbon, yet it resisted the draw-back temperature, as measured by Professor Carpenter's etching method, to a greater extent than any of the commercial tungsten high-speed steels used by him, whether of American or British manufacture.

It is possibly too early to make predictions, but the writer believes that molybdenum has established for itself a permanent place among the alloy steels found useful to the airplane, automobile and general engineering trades. It will not wholly displace any other type of steel, but the effect of improvements of this kind and new products has been rather to extend the field of usefulness than to eliminate products of previously demonstrated merit. The bessemer and open-hearth processes, and the electric furnace have not displaced the original crucible cast steel business. The demand for steels made by each method has arisen with the process itself.

Not only does molybdenum below 1 per cent give no trouble from volatilization, but it may be recovered from scrap when remelted in the open-hearth furnace to a large extent.



Courtesy Amer. Mus. Nat. Hist.

EARLY ORNAMENTS OF GOLD AND PLATINUM FROM ECUADOR

The Romance of Platinum

Recently Discovered Fields Which Yield this Most Precious Metal

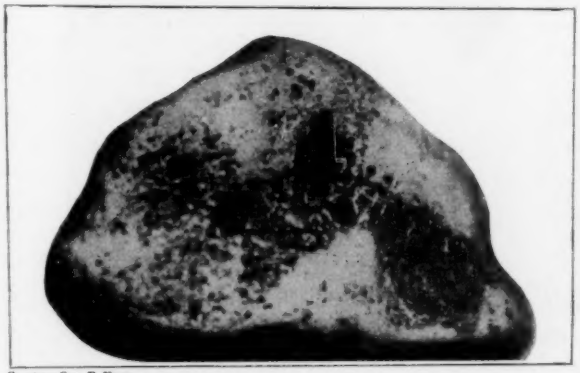
By Charles Henry Dorr

PLATINUM, one of the world's most precious metals, has an interesting history. It has eclipsed gold and silver in value and rivals ornamental gems, and in fact is only exceeded by the related metals, iridium and ruthenium, which are now worth considerably more.

During the Great War the use of platinum for catalyzing purposes in the production of concentrated sulphuric acid for the making of explosives, for dehydrating nitric acid, for airplanes and other war machines brought this metal into prominence. It is one of the two metals that possess at once malleability and ductility, and are not attacked by acids, namely, gold and platinum.

The wonderful ductility of platinum is realized when it is considered that a single troy ounce of the metal could be transformed into an almost infinitely slender wire that would reach from Santiago, Chile, across the continent to Rio de Janeiro, a distance of about 1,800 miles. To draw out platinum into such a fine wire it is necessary to cover it with a thin layer of gold. Such a slender wire would be practically invisible.

In the golden days of 1849 miners and adventurers were rushing to the gold fields of California in quest of fortune in the new Eldorado of the West. Gold was the magnet for the miner of that day.



Courtesy Geo. F. Kunz

SPECIMEN OF PLATINUM FROM COLOMBIA

Today the world's great treasure hunt is for platinum now worth about four times as much as gold, although its value has soared to as high as seven times its equivalent in gold. The almost universal demand for this precious metal has caused a world-wide search for it in the Ural Mountains of Russia where rich deposits of platinum exist, in the waters of the Condolo, Atrato and Choco Rivers of Colombia, and even in Alaska and the Arctic regions.

A new field of platinum has also been discovered in Spain along the banks of the Verde River and in the Ronda Mountains. Traces of this valuable metal have also been found in Australia, South Africa and Mexico.

There is not much question about the wide distribution of this precious metal, for it is found in almost all parts of the world, and while preceding the war Russia supplied 95 per cent of the production of platinum, later on it developed that much of this widely-sought treasure existed in Colombia, and this new field promises to yield much of the anticipated supply of the valuable metal in the near future.

It is singular that European knowledge of this wonderful metal dates back only about two centuries, although ornaments have been found in the pre-historic graves of Ecuador dating back some two thousand years ago, with traces of gold and platinum.

FIRST PRINTED MENTION OF PLATINUM

Perhaps the first printed mention of platinum may be noted in the title page of the book printed in Spanish, "Relacion Historica del Viage A La America Meridional," with Madrid imprint, the first volume of the account written by Don Jorge Juan and Don Antonio de Ulloa of their journey to South America in 1735, with the French expedition, to measure a degree of the meridian for the determination of the true figure and the magnitude of the earth. This work was published in 1748, and in it appears a mention of the metal platinum. It is here called "a stone of such resistance that it cannot easily be broken or reduced in size by a blow on a steel anvil."

For several years Dr. George Frederic Kunz, author of "The Book of Pearls," and widely known as a connoisseur of gems and precious stones, has been making an exhaustive study of platinum, and through his courtesy I am enabled to present the latest and most interesting developments concerning this wonderful metal called by some chemists "white gold," and including references in reports on platinum in Latin America, and information as to its production.

"It is indeed difficult to realize at present that in the first half of the past century," says Dr. Kunz, "after the discovery of platinum in the Urals, the Russian Government issued a platinum coinage, the intrinsic value of the coins being reckoned as less than six times that of silver and only a little more than one-third that of gold.

"The Russian platinum coinage, begun in 1828, in the reign of Nicholas I, consisted of 3-ruble, 6-ruble and 12-ruble pieces, worth at par $2.40, $4.80 and $9.60, according to the value of the ruble at that time; the coins contained about 2 per cent of iridium. The nominal worth of these coins was about $3,000,000, but the metal in them would now bring nearly $50,000,000."

It is interesting to note that as a precursor of the legal Russian coinage of platinum, certain Spaniards engaged in a counterfeit coinage of Spanish doubloons (gold coins worth about $8.24 from 1730 to 1772). Describing the process, Dr. Kunz says: "A piece of the same size was struck in platinum and the surface was then gilded as the specific gravity of the only partially refined platinum was approximately that of gold, so these spurious pieces could be circulated without much difficulty. In our day such a counterfeit doubloon would be worth intrinsically about $40.

"The Swedish chemist, Henry Theophilus Scheffer (1710-1759), is said to have been the first to call platinum 'white gold.' He says that its nature most closely approaches that of gold, so that it may justly be called 'white gold.'

"It was only in 1783 that a veritable platinum ingot was made by a European chemist. The honor of this accomplishment belongs to the French chemist, Chabaneau (1754-1842), who gained such a high reputation that the reigning Spanish sovereign, Charles III, called him to Madrid and created for him a special chair of mineralogy, physics and chemistry. He was given lodging in a palace and an annual stipend equivalent to $2,200."

Courtesy Geo. F. Kunz

WASHING FOR PLATINUM IN THE STREETS OF QUIBDO, COLOMBIA

EARLY ORNAMENTS FROM ECUADOR

"What are believed to be the oldest ornamental objects made of platinum were excavated in the province of Esmeraldas, Ecuador, by Mr. D. C. Stapleton. Most of these ornaments are made of gold and platinum combined, one or two thin layers of the latter having been hammered on to a thin layer of gold. They are thought to date back 2,000 years at least. Similar objects have been found in prehistoric graves in the Island of Tola, at the mouth of the Santiago River, Ecuador. These relics are now in the Museum of the American Indian, New York City." However these relics are not at present on exhibition but, with other specimens of precious metals, are reposing in a safe deposit vault, awaiting the installation of the collections in the Museum, which will be opened in the fall.

The American Museum of Natural History has in its collections some interesting examples of early ornaments of gold and platinum from Ecuador and presumably of the same period as the specimens in possession of the Museum of the American Indian. Through the courtesy of the American Museum of Natural History a reproduction is offered of these prehistoric ornaments, found on an island in the Santiago River, Ecuador.

It is the belief of Dr. Kunz that Spain was probably the first country to receive information in regard to platinum, and he says: "It was probably the first to receive specimens of the new metal, although the printed and dated records might seem to give the priority to England. It is perhaps something more than a coincidence that it was on Spanish soil that platinum was first discovered in Europe. The initial discovery was made at Guadalcanal in the province of Estramadura. Here it occurred in some gray silver ores."

NEW FIELDS IN SPAIN

Evidently there is a revival in prospecting for platinum in Spain for promising new fields have been located in the Ronda Mountains, near the coast, and about half way between Malaga and Gibraltar. It is reported that platinum has been found along the River Verde where much preparatory work has been completed by the prospectors seeking this precious metal, and work is also under way at Guadaiza.

According to reports from Spain the tract along the Guadaiza appears to be richer in platinum than that of the Verde region. The method followed has been to dig holes at intervals of two hundred meters and make soundings every twenty meters between each hole. It is stated that the provisions of law enacted by the Spanish Government several years ago closed the Ronda region to public search for platinum, with reservations for state rights in exploiting or prospecting.

The conditions of the platinum deposits of the Sierra de Ronda in Spain have been compared by Professor Louis Duparc with those of the famous Ural district in Russia with interesting results. He has arrived at the conclusion that three primary platiniferous deposits exist: "The dunite type of rocks, the most usual form, and also the richest; the pyroxenite type, rich in magnetite, and a form more rare than the preceding one, and the peridotite containing rhombic pyroxene in greater or lesser quantity."

Commenting on Professor Duparc's report, Dr. Kunz says: "The data as to deposits of this nature are still too insufficient to permit us to arrive at any justifiable conclusion as to their richness."

PLATINUM IN RUSSIA

Russia is the great Eldorado for seekers of the "white gold," and immense quantities of this highly valued metal are known to exist in the region of the Ural Mountains where many of the finest specimens have been located.

The Russian production of platinum averaged before the war 95 per cent of the world's supply and since the outbreak of the war no complete statistics have been available.

Platinum was first discovered in the gold mines of Dakovlov, in the Ural Mountains, Russia, in the sands of Naviansk, Bilimbayensk, in 1822, and in the Kurshinsk works in 1824. In 1825 the richest Uralian deposits were discovered. They were the sands of the Sucho-Vissimsk works in the district of Nizhni-Taglisk.

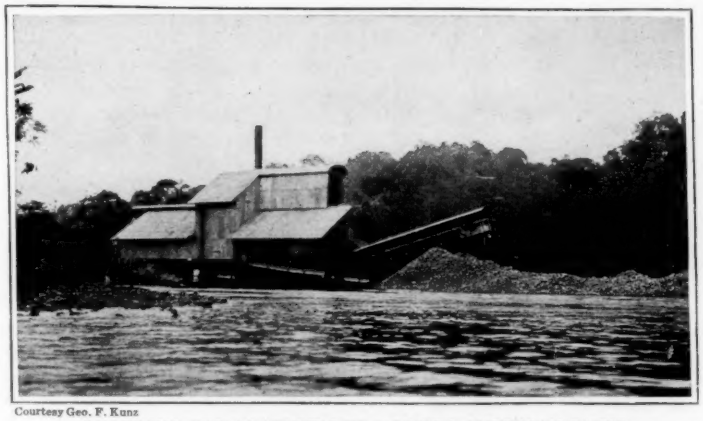
Daubrèe discovered, in specimens of the country rocks from the mines of the Tagilsk region, platinum in association with olivine, serpentine and chromic iron. In this famous platinum region the largest nugget in the world was discovered; it weighs 23.5 funts or 9,628.88 grams (25 pounds, 9.45 ounces troy). This specimen is known as the great Demidov platinum nugget, and its dimensions are 7 by 4 by 3 inches. The value of this remarkable nugget is given by Dr. Kunz at about $25,000, although it must have been worth more when

quotations for platinum were higher than present ruling prices.

In January, 1834, there was found at Martinov, where platinum was first discovered in the Urals, a slightly smaller nugget, weighing some twenty funts (21 pounds, 4 troy ounces, or 8,335 grams).

Juan Makarovich Belov in quest of gold in the Domidov mines of the Nizhni-Tagilsk region in 1825, discovered platinum. He found only a small amount of gold, but considerable of another metal, which upon being tested proved to be platinum. His discovery led to an extensive exploitation of this field, and by July, 1840, some twenty-one mines had been opened.

Perhaps the richest platinum sands are those of the Iss River, which flows through the eastern slope of the Urals from its source, and then follows a winding course for some thirty miles to the point where it merges into the waters of the Tura. Another tributary of the Tura, the Veeya is also said to be rich in platinum.



Courtesy Geo. F. Kunz

DREDGING FOR PLATINUM IN A SOUTH AMERICAN RIVER

Capacity of dredge, 400,000 cubic yards

The largest part of the Russian output of platinum since 1879 has come from the area of the Tura Valley, but before this date the Nizhni-Tagilsk region, more than one hundred miles to the southward, proved the most productive.

WEALTH OF TREASURE IN PETROGRAD

It is rather an interesting question as to what degree of success will attend the efforts of financiers to issue Russian currency notes secured by the stock of platinum in Russia. Cable dispatches have indicated a plan to issue notes of 50, 100, 500 and 5,000 rubles, the basis being an accumulated stock of platinum worth 37,500,000 gold rubles, equivalent to $19,290,000. The issue is to be limited to 65,000,000 rubles.

Some idea of the amount of gold and platinum in Petrograd when Lenine took command is gained through the statement that in November, 1917, there were in the vaults of the State Bank there more than $200,000,000 of gold in bars, and 25,227 troy ounces of platinum, 96 per cent pure, worth at the then ruling price of $104 a troy ounce, over $2,600,000.

There was a sale of platinum in Russia in March, 1919, under the control of the Omsk Government in Siberia. By its decree all producers were required to sell to the Government the entire quantity of the crude metal recovered by them. After the supposed value had been computed the producers were given half of the amount in Russian paper rubles, and the other half was only paid over (also in currency) after the metal had been disposed of by the State Bank.

It is the opinion of C. W. Purington, who has written a series of articles published in the *Echo*, that if the Iss platinum fields in the Urals were intensively worked by modern dredges it would yield an annual output for ten years of perhaps 300,000 ounces of the metal, but would then be exhausted.

However, other fields give promise of more inexhaustible supplies of this valuable metal, for as Dr. Kunz finds: "Owing to a variety of considerations, the Nicolai-Pavda region in Russia on the Kytlim River, and on the Lobva River below the place where it is joined by the Kytlim, seems to afford better prospects of good future results in platinum mining than any other known fields."

Prospecting work was begun in this tract in 1912-1913, although it had already been extensively worked by hand labor, and the forecast pointed to the existence of 26,000,000 yards of placer platinum ground, indicating prospective returns of over $8,000,000 for the exploiters. Just before the war these placers occupied the third position among the platiniferous areas of Russia, and as many as 5,000 men were employed there in the summer season.

Not much has been known in the United States of the company which was eventually formed to exploit these placers under the title of the "Nicolai-Pavda Mining Co.," for it was financed by the Anglo Russian Bank, and the shares were mostly dealt in on the exchanges of Paris and Petrograd.

The price of platinum has of course risen rapidly since the war, in Russia, as elsewhere, so that in 1918 the Nicolai-Pavda Co. increased its dividends to 8,000,000 rubles. As Russian exchange had not yet reached its present abysmal depth at that date, this means a larger sum of "real money" than it would today.

As to the platinum deposits of the Nicolai-Pavda region, Professor Duparc states that, of the three platiniferous centers, the most important is unquestionably that embracing the rich alluvial deposits of the Kytlim and the Lobva Rivers, those of the former having been partially worked, while those of the latter remain untouched.

Courtesy Geo. F. Kunz

ANOTHER DREDGE IN THE PLATINUM COUNTRY

Capacity of dredge, 1,000,000 cubic yards

As Russia will probably continue to yield the largest supply of platinum in the future as this country has in the past, the merger of the Russian Economic League with the American Chamber of Commerce is of interest to those in need of the valuable metal.

The League has already accomplished much in bringing American and Russian business men into contact. Hon. William C. Redfield, formerly U. S. Secretary of Commerce, is president of the American-Russian Chamber of Commerce, which includes a number of other representative men.

PLATINUM FIELDS IN COLOMBIA

For several years attention has been directed to the platinum deposits of Colombia, and according to Dr. Tulio Ospina, director of the School of Mines at Medellin, Colombia, a vast area of over 5,000 square miles exists containing gold and platinum in the region lying west of the central ridge of the Colombian Andes, in the drainage basin of the Atrato and San Juan Rivers, and extending south of the latter to the Mira River. It is stated that a much larger proportion of platinum to gold is found in the gravels of the San Juan River than in those of the Atrato, the two metals occurring in about equal quantity in the former, while in the latter the proportion is about 35 per cent of gold to 15 per cent platinum.

The most productive area is controlled by English and American capital, and the formation of a United States of Colombia Exploration Corporation with considerable capital is of importance, for it is predicted that it is to Colombia that we must look for most of the supply of platinum during the present year.

A dredge has been operated on the Rio Condolo in Colombia with successful results and others are projected for use in this region.

The Republic of Colombia has laid a tax of 5 per cent ad valorem upon all platinum exported from that country after June 15, 1915, and it is anticipated that if the increased supply of platinum materializes in the Colombian mines the treasury of that Republic will be considerably enriched.

It may be of interest to note the increase in the importations of platinum from Colombia to the United States for a period of say eight years. In 1910 for instance, the value of platinum imported from Colombia to the United States was $31,383, and for the fiscal year ending in June, 1913, the importation of this metal had increased to the substantial sum of $2,241,744.

So Colombia promises to be a rich platinum field in the future.

Referring to the production of platinum in Colombia the Pan-American Union composed of twenty-one American republics states: "Colombia produces an average of 30,000 troy ounces of platinum a year, practically all coming from the Quibdo district.

"The high prices prevailing during the war greatly stimulated the production of this important metal, and entire districts along the coast and rivers west of Cartagena were depopulated, the people emigrating to the platinum district to wash for platinum gold.

"The Atrato and Choco Rivers are tributary to Cartagena commercially. Therefore merchants in Cartagena are the heaviest buyers of platinum and gold from the placers of these rivers and also supply the merchandise needs of the region through their agencies established in Quibdo, Istmina, and Baudo. The development of water transportation of the San Juan River has taken some of the trade away from Cartagena, and the district has also been invaded from Medellin by traders from Antioquia. During the war the United States took almost the entire platinum output of Colombia."

TOWN TURNED INTO A MINE

The rejection of platinum as waste in the operation of refining gold was the cause of some odd incidents in Colombia. When platinum became valuable a considerable quantity was discovered in Quibdo, capital of the Choco district, where much gold refining took place, and as a result the entire town of some 1,500 inhabitants was transformed into a mine. Property owners mined under their houses, and tore down their buildings in their quest for the hidden treasure. One merchant was not only enabled to rebuild through platinum mining, but also cleared $4,000 in American gold. Some of the platinum separated from gold by the dry or "blowing" system was wafted into the streets or the cracks of buildings.

Colombia probably ranks second in the world's production of platinum, although far behind Russia in the output of this precious metal. There is a prospect, however, that Colombia may overtake Russia some day, and take first place as the richest platinum region in the world.

PLATINUM FIELDS IN ALASKA

A bill was introduced in Congress in September, 1919, for the incorporation of the "United States Platinum Corporation and to aid in the development of the mineral resources of Alaska and for other purposes," which would indicate that vast fields of platinum exist in that country. The capital stock was not to exceed $50,000,000, and it was to be exempt from Federal taxation, and empowered to receive concessions and leases of government-owned platinum sands in Alaska. Prospecting has been carried on in two localities in Alaska for platinum, one of these on a tributary of the Kahilna River, and the other several miles below the mouth of Peter's Creek.

Although it is not generally known when Captain Joseph E. Bernier, a noted explorer, returned from his last expedition to the Arctic regions, he announced to the writer that he had located some important "finds" of platinum in the Far North. He did not describe the exact locality of these fields, but they are known to exist and probably will be exploited in the future. Thus far Canada has not produced any great quantities of platinum.

SUBSTITUTES FOR PLATINUM

THE need for a satisfactory substitute for platinum is making itself more and more urgently felt. For certain uses an alloy of nickel and iron may take the place of platinum. This alloy, to which the name of "platinite" has been given may be used in incandescent lamps. Nickel-chromium is sufficiently resistant to chemical action to render it a fairly good substitute for platinum in the laboratory. Cobalt is even better than nickel when in contact with strong acids. The low melting point of gold makes that metal unsuitable for some purposes, but this point may be raised by the addition of palladium. This alloy, called "palau," from the Latin name of its component elements, has been tested by the Bureau of Standards at Washington and found to be superior to platinum in some respects, though inferior in others.

FUTURE FUEL

DR. J. HOWARD MATHEWS of the University of Wisconsin in discussing probable sources of future fuel before the Chicago section of the American Chemical Society emphasized the importance of photo-chemistry and the possibility of perhaps some day finding a catalytic agent which would make it possible to combine water and carbon dioxide to form a carbohydrate from which alcohol might be produced.

"With constantly diminishing reserves of fuel," said Dr. Mathews, "the question of the utilization of the radiant energy from the sun becomes more and more of a live question. What will the world do when fuel is gone? Such a possibility is, at least geologically speaking, a question of the almost immediate future. Hundreds of millions of horsepower of energy are coming continuously from the sun. How can this energy be stored up and transformed into a useful form of force? The optimistic photo-chemist believes that it can be employed to bring about certain chemical reactions, which, by their reversal, will again liberate it, preferably in the form of electricity. The dream is no more chimerical than was that vision of a hundred years ago, in which electricity was conceived as stored and utilized."

Chlorophyll, which imparts the green color to leaves, is believed to be a sort of catalyst which in sun light enables the combination of water and carbonic acid gas to go on forming the starches and sugars of plants. The present task of the photo-chemist is to study all possible types of reactions produced by all kinds of radiation, for in no other way can a thorough knowledge of the laws and principles involved be gained.

When these laws are understood the future may give us many important practical applications.

GUIDE AND CLIMBERS PROPERLY ROPED ON THE "EISMEER." THE ROCK GALLERIES OF THE EISMEER STATION OF THE JUNGFRAU RAILWAY ARE SHOWN ON THE LEFT

"Mountain Craft"

Personal Regimen, Walking Manners and Equipment for the Climb

Reviewed by A. A. Hopkins

Fellow of the American Geographical Society

IT was not until after the war that a number of books on "Mountain Climbing" appeared, as of course an amusement of this kind could hardly be indulged in during the stern war period, although mountain climbing is often productive of extremely scientific results. A mountaineer is not only one who climbs mountains, but one who likes to walk, read or think about them. As in any other sport book-learning is of limited value, but there are certain fundamental facts which are of service, that can be learned from books. We have just had the privilege of examining a recent work on the subject, "Mountain Craft," by Geoffrey Winthrop Young.* The present article will be regardel to some extent as a review of this book plus such information as is now obtainable as a result of correspondence with Swiss authorities. The whole subject is very interesting in view of the projected ascent of Mt. Everest, the tallest mountain in the world.

The advice which Mr. Young gives is admirably supplemented by chapters by specialists. Mountaineering, in its wider aspects, can only be learned by experiment, and even the natural climber may be able to get some guidance from the collective expression of other men's mountaineering experience. Many efficient climbers, again, never bother themselves at all with mountaineering as a craft. They simply take its pleasures and leave its responsibilities to guides or to chance. Most of us are, in a sense, specialists: interested in one department alone, and neglectful or ignorant of the rest. For such of us there is some benefit in surveying, if only superficially, the immense field that a man must set himself to traverse who aspires to lead a party safely.

*Published in U. S. by Charles Scribner's Sons, New York.

A party consists usually of from two to four climbers, exclusive of guides. A larger number inevitably divides into two or more units for mountaineering purposes. The management devolves upon the most experienced mountaineer. His selection as leader, in this sense, is more often than not tacit and unexpressed, especially among British climbers. Over-management is fatal to the effective coöperation of a party: and a formal selection of a leader, or a precise insistence upon the performance of particular duties by individual members may only disturb the pleasant relationship of friends on a climbing holiday. If a man is not felt to be qualified as leader by personality and experience no vote will make him so. If it is the duty of the young mountaineer to learn to accept a constitutional authority for the good of his party, it is that of the leader or manager to see that it is used only for the good of the party and to make it personally the less obvious, the more it grows to be accepted in understanding.

PERSONAL REGIMEN

There is no need to bother overmuch about the party before the tour commences. Of course men, for their own sakes, will come as fit as they can. Attention to the diet and, if it can be got, some regular exercise in the open air, such as walking, running or tennis, but the author has never seen any particular benefit accrue from exercising particular sets of climbing muscles. The first few days of the tour, however, are vital. Mountaineers are sound men, and have usually only two weak points, the feet and the stomach. New boots or overwork attack the first; unaccustomed food, chang-

ing atmospheric pressures, and revolutionary hours of sleep, food and exercise upset the second. For the feet precautionary measures are the safest. In ordinary life we accept their constant service unconsciously, and it requires an effort to give our own, and even more, other men's feet the additional attention they require on the first few days of any tour. To see that the boots fit, on the second day even more than on the first; to make sure that one or even two extra pairs of socks are put on if any boot has become stretched after wetting; to discover if there is any beginning of rub or blister, and to check it by boracic acid powder or ointment in the sock at once, even if this means a halt in the middle of the climb; to suggest bracing with cold water in the evenings or whenever opportunity offers, in the case of anyone whose skin is tender; to double these precautions—these are some of the first duties of management.

Internal chill is a constant risk during the first few days of exposure to unaccustomed changes of temperature. Damp clothes next to the skin are principally to be avoided. A spare vest or a flannel shirt should always be taken in the sack, for a change at hut or bivouac, even if the other clothes have to be worn wet or slept in. In a hut it is preferable to take the wet clothes off and to sleep rolled in a blanket, even though that may be also damp. During the day it is unwise to sit on damp or cold rocks. A coil of rope may be used as a seat, or a useful habit is to carry a small square of waterproof, in which the spare shirt can also be wrapped. When nearing the hut it is well to reverse the usual practice and go slow for the last twenty minutes, so that the perspiration may dry gradually from the body while in motion, and not after it is at rest. By the fire in the evening, during the snooze on the summit, and especially in an enforced bivouac, the stomach is the vital point to protect. In case we get benighted any spare clothes or even paper should be wrapped round the stomach. The coat should be taken off and fastened round the shoulders outside the arms, so as to concentrate all the body's warmth within it. The feet can be put in a rucksack. If possible, the boots should be kept on, to avoid their freezing hard. If they have to come off so as to save the feet from frost-bite, they should be sat upon, to keep them soft. Wind is another enemy to guard against while resting during the day or sleeping out, and a light wind-cloak is a sound protection. On returning to the hotel, a hot bath, if procurable, or a hot sponge-down, should always be taken; it not only clears the pores and supples the muscles, but it restores the normal circulation and removes congestion, due to great exertion and changing temperatures, which often produces a general feeling of discomfort, especially in the head.

FOOD AND DRINK

Care in the choice of food, discouragement of the inclination to starve during the day and to overeat in the evenings, insistence upon a regimen to new time-table, and, in case of failure, the employment of the simple domestic remedies at once and in time, these are all indispensable during the first days. In the matter of the choice of food the leader has to overcome the repugnance natural after a satisfying evening meal to attend himself to all the rather messy details of provisioning for the next day. No guide or hotel-keeper can be trusted to do this. During the first days of hard exercise the average man will eat but little food, and turns from meats and tinned goods such as hotels love to load into the sacks. He has to be tempted with sweetstuffs, jams, chocolate, and meat-essences and eggs for support. The disposition to eat little during the effort of the first days and to eat largely in the reaction of the evenings, has to be countermined by the offer, at not infrequent intervals, of pleasant luxuries that go down easily. It is old-fashioned and entirely wrong, especially with young people, to give them only what used to be termed wholesome, nourishing food. In healthy open-air conditions the body knows what it wants, and the palate interprets the desire. Food that is not palatable or eaten with pleasure is of little benefit, and cloying sugar compounds, the best muscle fuel, become again surprisingly attractive.

Thirst is another difficulty at the beginning of a tour. To a large extent such thirst is merely feverish; it is impossible of satisfaction, and to indulge it swamps and upsets the human machinery. Some resolute men, to avoid the delicious temptation, train themselves not to drink at all during the day, and then make it up in the evening. But a certain amount of liquid is as essential, in action, as a certain amount of food, and the moderate habit has to be acquired by practice. The exact amount necessary, as distinguished from acceptable, varies with the individual. The merely feverish thirst of the first day can be dodged by letting water run through the mouth, swallowing, as a special indulgence, only a mouthful or so. Sucking a prune-stone or even a pebble, keeps the saliva flowing and is a consolation on hot snowy tramps. To the same end, of prolonging the pleasant assuaging process, devices such as sipping water slowly from a pearl-shell or cup cool

SNOW WORK—THE JUNGFRAUJOCH DISTRICT, SWITZERLAND

to the eye, chewing orange peel, sucking a lemon or tea slowly through lumps of sugar, or crushing a handful of snow till it becomes an ice-pear in the hand and then sucking the end of it, are all worth remembering.

WALKING MANNERS

There are several points of what may be termed "walking manners," common to all types of long mountain walking and not only to climbing, whose observance contributes a great deal to the individual peace of mind during the early and late hours of a long alpine day. Men when they are off the rope, or who have never been on a rope, almost universally neglect them, and are blind to the cumulative effect upon a tired companion's temper or upon their own humor.

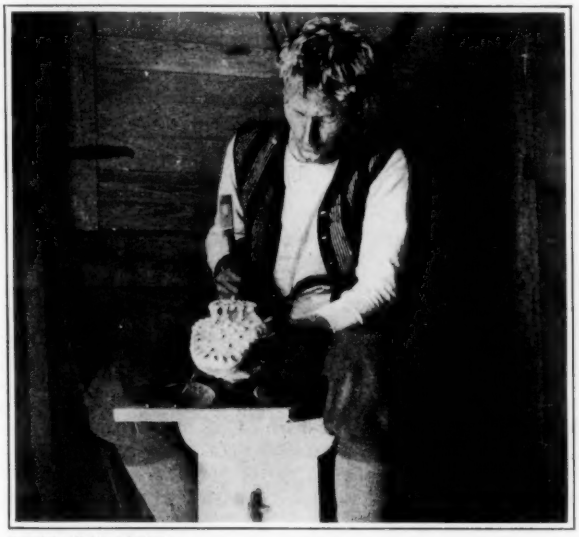
The first point of manners for the man in control is that of pace. Most climbers suffer from the weakness of increasing the pace the moment they take the lead on a path, slope or glacier. This is trying to the party, consciously or not, and wasteful. A manager should either block the way himself, or, if he is behind, keep consistently to what he considers the right tempo.

A second and frequent failing is the "half step" trick. Some fifty per cent of fast walkers, whenever they walk abreast on road or path or hill, persistently keep half a stride in front, their shoulder just clear of their companion. It may be due to some half-formed feeling of satisfaction in setting

the pace and having a margin to turn round and talk from. Its effect is that the friend is perpetually straining to catch up, and the pace thus steadily accelerates till both are practically racing. Then one gives up, and both lag until the game starts again.

A third breach of manners, all too common, is passing ahead in the line of march. Over most broken country, glacier, snow or rough hillsides men naturally fall into single file. Cattle tracks or man tracks are rarely wide enough for two abreast, and if it is a question of selecting a line, it saves reduplication of the effort to leave the task to one and to drop in behind him. There are few inexperienced walkers who do not take advantage of the slightest error in the choice of route on the first man's part, to break off and pass him on the shorter line. In doing so they take the responsibility of taking all the rest who follow, off the line also. On an ordinary hill walk, when the going is all free and easy, this is excusable. But, done as by one of a line of men either tired or with a big day before them, where one has been taking the extra burden of route-selecting for the rest, it is a serious breach of mountain manners.

A more debatable occasion, where the same point comes into



Copyright, Kadel & Herbert

CAPTAIN FINCH WHO WILL TRY TO WREST THE SUPREMACY IN MOUNTAIN CLIMBING BY THE SCALING OF MOUNT EVEREST, REPAIRING HIS CLIMBING BOOTS

prominence, is on the ascent of steep slopes or open hillsides. An experienced front man will probably take these on a zigzag. To a less experienced walker, and to all beginners of energy and leg muscle, it is generally a temptation to cut the zigzags on the direct line, and so pass ahead. This is bad walking, but there is the more excuse for it in that on such slopes men rarely do follow each other exactly and most of the party will probably be preferring each to take his zigzag at the most comfortable angle to himself. The best rule of manners to remember is that, while every man is free to choose any line and pace he likes on such places, yet, if one man has been definitely leading and choosing the line, the others ought to drop into their places in the line behind him again so soon as the single-file formation is resumed.

Another blunder, from which many a good walker is not free, is the inclination to hurry the pace if the line or short-cut he has chosen takes the party for a while over worse ground, or proves, for other reasons, not to have been the best route. His almost unconscious acceleration is due to some impulse to get back quickly and unnoticed to good going, and so to slur over the mistake, or the momentary disagreeability of the route for which he is responsible, as much to himself as to those who follow. It is a trick to notice and avoid. It forces the rhythm and pace over just the ground where it should, if anything, be eased.

Again, when walking in single file, or any way but comfortably abreast, men inexpert in acting as guides do not realize that although the man in front can hear all that is said behind him, yet that, unless he turns his head over his shoulder and throws his words out, he himself is inaudible down the line behind him. As the remarks from the leader on a long tramp, and when men are tired, have usually some direct bearing on the way, those behind him crowd up to hear; they break step and are often put irritably on the strain. These matters may seem too slight to mention, but neglect of their observance brings many a party home with some member or other out of harmony and unappreciative of the sunset.

THE WEATHER

There is one variable which belongs to the mountaineering rather than to the human division of the problems with which management has to deal. The weather is the background, foreground and middle distance of all big mountaineering. A change can upset the nicest adjustment of a climb to the strength of a party or to the length of a day. Every climber keeps one eye on this irresponsible neutral, which may at any time turn the scale of the campaign against him. The scientific study of weather, and its prediction by the barometer and thermometer, are matters for a whole book, and the authoritative text-books are available. Instruments larger than of pocket size are something of an encumbrance to a climbing party.

Even more than the clouds, once we have discovered the habit of the year and the local signs, the winds are our firm basis for forecast. The north wind in the Alps is usually for good, though in a bad season of habit it may, if long continued, bring snow. The south wind is always fraught with suspicion, until it justifies it. It brings a succession of storms, but leaves fine intervals. The west wind, if continuous, means the continuance of unsettled weather, with an inclination to preserve whatever may be the habit of the year. It is perhaps the most forcible and trying of winds to encounter on the ridges exposed to it. The east wind is infrequent and rarely long continued. Its portent is favorable. The southwest wind means rain to follow. A change from north to northwest threatens rain. A change from southwest to northwest—generally a wind on its way to becoming a north wind—means a change for the better in bad seasons. Southeast, and especially northeast, winds share the good qualities and projects of the east wind.

A red sunrise is bad; a red sunset good. Sunrise on a gray sky means a fair day; sunset on a gray or pale yellow sky means a rainy day, on a bright yellow sky a windy day.

A "high dawn," the sun showing first over a vapor belt, is an ill sign; a "low dawn," the sun leaping from the horizon, a good sign.

If the distant sky at dawn, especially to the west, is low and dark, there will be breaking weather by noon.

A dark blue sky tells of wind and probably rain to follow; a light blue sky is of fair weather.

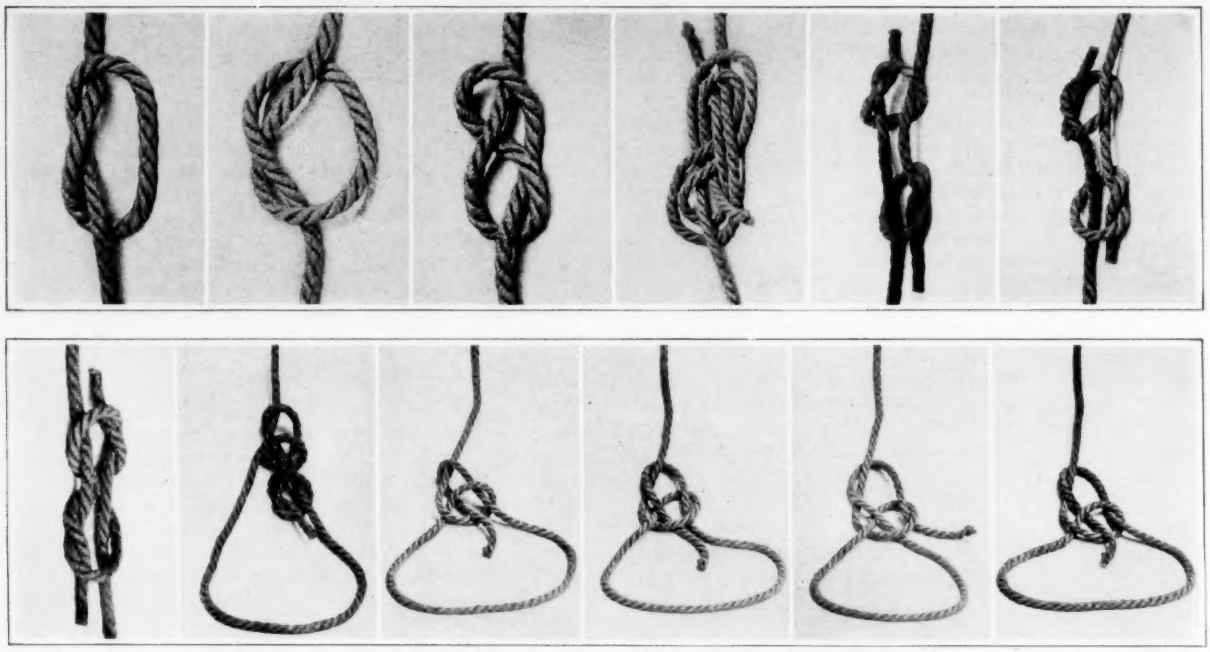
All over bright or gaudy colors at sunrise or suset, and all hard outlines, foretell rain and wind. Delicate colors, well-blended tones and filmy cloud edges are fine weather prophets.

Rings around the sun or moon, and vivid twinkling stars in the later night are bad signs. Clear nights of cold, and calm and quiet stars before dawn are good.

Heavy dews and the falling of the wind at sunset are good signs.

The clearness and nearness of distant hills, except just after rain, is a bad sign; but there we may distinguish between a clear landscape when we face toward the sun, which is an ill sign, and a clear landscape as we stand with our back to the sun, which is quite usually a fair sign.

Ascending mists on hillsides are bad. Mists in valleys at



FIGS. 1-12. CORRECT AND INCORRECT METHODS OF TYING SOME MOUNTAINEER'S KNOTS

Left to right, upper row; 1, Thumb knot, correct; 2, same, incorrect; 3. Figure of 8 knot, correct; 4. Figure of 8 tie, correct; 5. Single fisherman's bend, correct; 6. Same, incorrect. *Lower row.* 7. Single fisherman's bend, incorrect; 8. Bowline and overhand knot, correct; 9. Bowline, correct; 10-12. Incorrect forms of bowline knot

evening, clouds lifting at sunset, and hilltops smoking their pipe of evening peace, are good.

Warm airs as we pass up the lower alps or through the pinewoods mean us well; but warm nights on the height and in the hut, or the sickly puffs of warm breath that meet us from the large crevasses as we start up the glacier before dawn, are omens of ill weather.

Early rain, "rain before seven," has no serious meaning; it rarely lasts.

Early white mists should never frighten us from starting, but we must judge them by feel, texture and direction of movement. An early ominous mist has a different quality, and lies differently from a simple mist of the hour.

MOUNTAIN CLOTHING

The second chapter of Mr. Young's book deals with equipment for the Alps and is written by Capt. J. P. Farrar, and forms one of the most interesting sections of the book. Too much attention cannot be paid to the question of equipment and Captain Farrar's recommendations are based on the experience of a great many years' active service in mountaineering. He recommends very stout cowhide, unlined boots, worked to the softness of thick buckskin. He says very justly that the ordinary boot maker knows nothing about the alpine boot and those who are thinking of extensive mountain excursions should consult those who make a specialty of outfits for mountain climbing. An unlined boot will dry very quickly if stuffed with dry paper, hay, straw, or oats and will be very supple if treated with a little castor oil before each expedition. Captain Farrar goes into the question of nails in considerable detail. These nails of course can only be obtained from dealers in alpine supplies and can easily be secured in Switzerland. He specifically recommends the "Tricouni" nail, which we illustrate. These are set close to the edge of the sole and continue right up to the heel. These nails can be used for the tread of the soles, or almost preferably half a dozen wrought-iron hobnails suitably spaced. The plates protect the sole and give a firmer stand than the ordinary nail. Captain Finch's shoes are a good example of a well-protected sole. Captain Farrar recommends a soft sock of Norwegian natural wool which can be obtained from alpine centers or in London.

A coat of stout tweed is recommended, especially those which are made shower proof. He specially objects to lining, except to protect the outside of the arm from the shoulder to the elbow. The buttons should be closer than usual, so as to keep out the driving snow. The idea is that an unlined coat will dry far quicker than a lined coat. Knickerbockers of the same cloth are recommended. A light woolen sweater and a light woolen muffler about one foot wide and six feet long is recommended, especially for very cold weather, or for sleeping out, when it can be tied twice around the stomach and fastened with safety pins. A light water proof cape of Japanese silk can be procured, which weighs only about one-half pound. Long gloves are also recommended. A tam-o'-shanter is approved in place of a cap.

EQUIPMENT FOR THE CLIMB

The outfit should be carried in a "rucksack," which can be obtained from all sport outfitters. The question of ice-axes is an important one and there are innumerable types supplied by alpine outfitters; an approved type should be used, and the axe should weigh about three pounds. We give two examples of ice-axes selected from various sources.

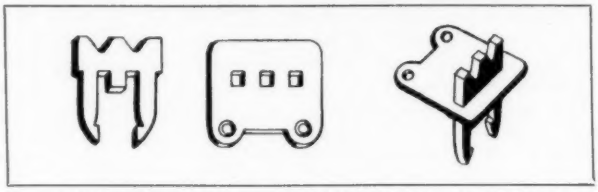
The question of rope is a most important one and flax rope seems to be preferable. Such rope can be secured in London or in climbing centers. What is known as "left-hand" alpine rope is recommended by Captain Farrar, and we have been able to examine samples of it through the courtesy of London climbing outfitters. It is beautifully flexible to handle and knot, and after the first wetting, shows no tendency to kink. The author in this chapter makes very pertinent suggestions relative to rope in connection with mountain climbers. He says for haulage of "duffers," where the rope is constantly dragged against rocks, no doubt a much heavier rope of Manila, or possibly "wire rope" would be preferable. The rope should not show undue wear during a single season. Captain Farrar never uses rope a second season for life may depend on its strength and a new one can be purchased for a few shillings. Even when the rope shows no appreciable wear, it may have been subjected to some sudden severe strain which has robbed it of a portion of its virtue. Captain Farrar says that used ropes ought not to be given away to guides who

will go on using them for an indefinite time. This is good advice.

With respect to knots for use in alpine ropes, Mr. Eckenstein was again good enough, says Captain Farrar, to investigate the question, and the accompanying illustrations have been prepared from photographs taken under his instructions. They are all applicable to a "left-hand" rope.

The following is an extract from his letter to Captain Farrar:

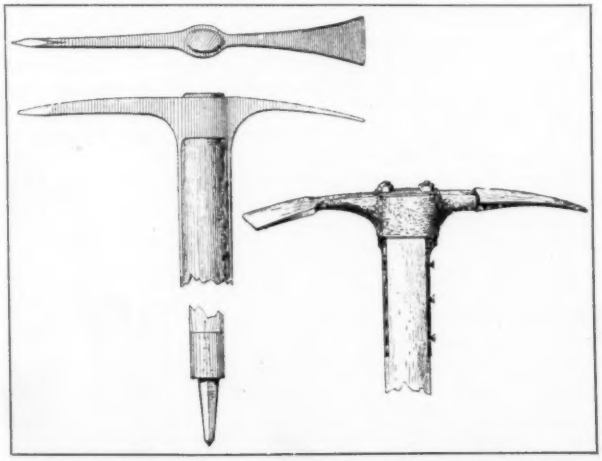
"A laid rope usually consists of three strands twisted together. Each strand thus forms a helix. The strands are 'laid' together to form the rope, and the way in which they are laid together is called the 'lay.' Now if we begin to tie a knot, we similarly 'lay' together, two ropes, and each rope then forms a portion of a helix. The general rule is this: If the strands of the rope used form right-hand helices (as is the case with the old Alpine Club rope), then in that part of the knot which is subjected to the greatest strain (I use the word 'strain' in its popular sense) the two ropes must each form a left-hand helix. Conversely, if we use a rope, the strands of which form left-hand helices (as is the case with the new Frost rope), then in that part of the knot which is subjected to the greatest strain the two ropes must each form a right-hand helix.



CONSTRUCTION OF THE TRICOUNI NAIL FOR SHOES

"The annexed figures include three classes of knots: simple or elementary knots; knots for uniting two ropes; loop knots. All are shown tied with left-hand rope. The correct way of tying the knots is shown in each case, as well as some incorrect ways. Each knot is shown open, before it is drawn taut.

"The single fisherman's bend, shown in Fig. 7, is excellent for uniting two ropes of similar size for temporary purposes, as it can readily be undone. Hence, it has a tendency to work loose in course of time, and if it is necessary to unite two ropes of similar size for longer periods, it is better to use the figure of 8 tie also known as the Flemish tie, shown in Fig. 4. This, though somewhat complicated, is strong and reliable and has no tendency to work loose.



PILKINGTON ICE AXE (*LEFT*) AND KENNEDY AXE (*RIGHT*)

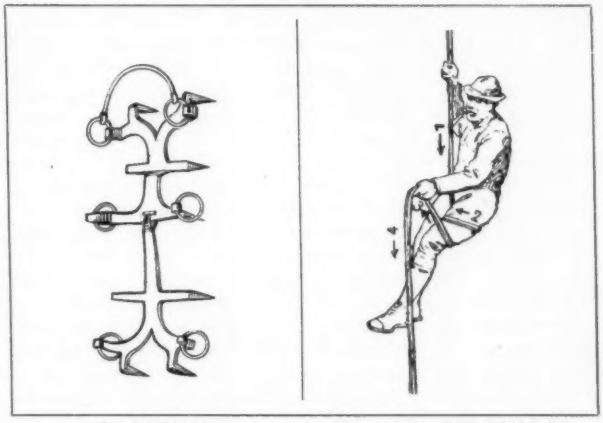
"As regards making a loop in the middle of a rope, no entirely satisfactory knot has yet been devised. The 'middleman noose,' shown in the 1892 Alpine Club Report of the Special Committee on Equipment for Mountaineers, has the fatal disadvantage that under certain conditions, when a pull is applied in a certain direction, it acts as a true noose—that is, as a slip or running knot. The best middle loop at present known is the open-handed loop, which is free from this disadvantage.

"For an end loop, the bowline, shown in Fig. 11, is excellent. The loose end should be secured by half-hitch, or by an overhand knot; the latter, shown in Fig. 12, is preferable."

New rope should be wetted or stretched before use, and the kinks should be carefully worked out by hand. Wet rope should be dried in the shade. The best length of rope for a party of three is 100 or 120 feet.

Crampons add security and are very useful in saving step-cutting on great ice climbs. We illustrate a typical crampon. Crampons are not for use on rocks, except possibly when iced, but they are particularly necessary on steep grass mountains.

Both spectacles and grease are very necessary on glacier expeditions. The spectacles are either of smoked glasses or colored glasses, particularly of green-yellow. Special grease should be used for the face and blackening the face and all round the eyes with burnt cork is also an efficient remedy against sun burn, and suffices in case of loss or breakage of glasses. Captain Farrar recommends a monocular glass rather than field glasses, which are too cumbersome. A light aneroid reading to about 5,000 meters and a compass should form a part of the equipment of all mountaineers, particularly the compass. He is not in favor of cooking apparatus, as he considers cooking on an expedition takes too long and is a needless luxury. Food already prepared should be taken. Tents, sleeping bags, etc., can be secured of the proper variety from all alpine outfitters. A few simple remedies should be carried in rucksacks.



TEN POINTED CRAMPONS

USE OF SAFETY KNOT IN DESCENDING

OTHER CHAPTERS

The third chapter of Mr. Young's book entitled "Guided and Guideless Mountaineering," is a thoroughly scientific discussion of this important subject.

The chapters on rock climbing, climbing in combination, ice and snow craft, reconnoitering, mountaineering on ski, mountain photography, special chapters relating to mountaineering in tropical countries, mountaineering in the Arctic, the Caucasus, Corsica, Himalaya, the Mountains of Norway, Southern Alps of New Zealand, Pyrenees and the Rocky Mountains are all very interesting.

A chapter relating to Himalaya is written by Mr. T. G. Longstaff. It is of particular value in view of the coming ascent of Mount Everest. This book is one of the best works on mountaineering which has appeared for many years.

For our frontispiece and the photographs reproduced on pages 551 and 552 we are indebted to the Federal Swiss Railways.

Research Work of the United States Bureau of Standards

Notes Specially Prepared for the SCIENTIFIC AMERICAN MONTHLY

REFRIGERATION CONSTANTS

FOR a number of years the Bureau has been conducting researches on the determination of the thermal properties of materials, so far principally the media used in the production of artificial refrigeration.

This work has involved, first, the procuring of the fixed equipment required; second, the selection and training of a staff of investigators capable of carrying out the refined physical measurements necessary; third, the development of methods of measurement suitable for the considerable range of temperatures and pressures involved and the construction, testing, and installation of the special apparatus required; fourth, making the measurements and preparing the results for publication in scientific papers, and making the results available for use by tabulating them in the forms required in engineering practice.

The work so far completed deals with the specific heats of brines, the specific and latent heats of ice, and the specific heat, latent heat, and vapor pressure of ammonia, and with heat transmission through insulating materials and structures. The work completed on ammonia serves as the basis of a complete table of thermodynamic properties of the liquid and saturated vapor, for use in refrigerating engineering. Work on the properties of superheated ammonia vapor is under way and should within the year yield data to complete the tables of properties of ammonia. These tables will be the equal, if not the superior, in point of accuracy, of existing data on the properties of steam. The methods and apparatus developed during the work on ammonia are available and should be used to measure the properties of other media now being used in refrigeration.

When we consider that existing tables are based largely on the work of Regnault done 50 or 60 years ago, it is obvious that systematic measurements of this kind should be made with modern facilities.

It should be pointed out that the work which has been completed thus far is of enduring scientific and engineering value. The best available modern instruments of precision measurement have been utilized, the accuracy that has been attained is high, anl the results have been checked in every instance by independent methods of experimentation and often by entirely different experimental equipment and by different observers.

Of the several steps involved in such a program and enumerated above, the first three are largely completed. The present program contemplates extending the work to the determination of the properties of materials other than ammonia, thus utilizing efficiently specialized experience and equipment which has been accumulated. Materials on which work is contemplated include carbon-dioxide, ethyl and methyl chlorides, and perhaps sulphur dioxide.

WHITE COAT CAST IRON ENAMEL

ENAMELS of this sort are largely used by stove manufacturers and the chipping off of the enamel has been a serious problem in this class of work. The Bureau is conducting an investigation of the subject and during the past month nine ground coats have been prepared and applied to a number of cast iron samples. It was found that smelting some of the compositions by the frit-crucible method gave unsatisfactory results because of the chipping of the ground coat when applied to the iron. Duplicate mixes were, therefore, prepared by fritting in the kiln at lower temperatures and the preliminary results would indicate that this method is preferable. The comparative tests are being continued and it is believed that considerable information will be gained regarding the effect of various methods of smelting which will form an important part of the investigation. Ground coats which previously have given trouble from blistering with more or less refractory cover coats are working satisfactorily with cover coats of a more fusible nature. It appears, therefore, that it will be necessary to develop a number of typical fusible ground coats to be used in connection with the softer cover coats which are desired by certain of the stove manufacturers.

LOOKING INTO THE CYLINDER OF A GASOLINE ENGINE IN OPERATION

THE first tool used by the investigator is usually the eye. He sees a thing happen and the first step in his investigation is likely to be the obtaining of a telescope, microscope or something to enable him to see more clearly.

In the development of the internal combustion engine, however, visual observation of the combustion has played a minor rôle. To be sure, early investigators did provide apparatus that permitted them to look in the cylinder while the engine was operating, but little has been done in this direction with engines operating at the high speeds of the present day automobile types. Interest has centered in what an engine could do rather than how it did it. As a result, measurements of brake horsepower and fuel consumption have been deemed of first importance.

At the present time, the cry for fuel conservation has reawakened interest in the nature of the combustion in the cylinder. Glass induction systems have disclosed how satisfactorily, more often how unsatisfactorily, the fuel has been prepared for combustion. Analyses of the exhaust gases have shown how completely, more often how incompletely, the charge has been burned. If studying preparation for and results of combustion is of value, an actual study of conditions during combustion should surely be worth while.

This has been accomplished in connection with the study of combustion in the one-cylinder Liberty engine at the Bureau of Standards in the following manner: A spark plug shell has been adapted to receive a circular section of glass intended to serve as a window in the cylinder. This assembly can be used in place of either spark plug in the ordinary aviation cylinder, but in this instance an additional boss has been welded to the cylinder in order that conditions might be observed with both plugs firing. Its use was satisfactory in that changes in flame color due to changes in air-fuel ratio were easily discovered. Since the entire combustion stroke is completed in one-sixteenth of a second at an engine speed of 1,800 r.p.m., it is possible to see only the predominant color of the cycle by this means.

To make it possible to observe the combustion in its various stages, another device, a stroboscopic disk, was added. Its purpose is to permit the combustion to be observed during only a small portion of the stroke. Since there is one power stroke for every two revolutions of the crankshaft, this disk is driven at one-half crankshaft speed. The flame is observed through a slot in the disk, the length of the slot governing the length of the portion of the stroke studied. Provision is made for altering the angular relation of this slot to the crankshaft so that any interval of the cycle and, hence, any stage of combustion can be studied.

Observations made possible by this apparatus are not likely to replace any of the more usual measurements. They may, however, prove, and in fact have proved of considerable value

in research work of the nature described by permitting observations of the duration of luminous flames during the power stroke, the characteristic differences in color and brightness at different phases of combustion and their variation with changes in ignition timing, mixture ratio, compression pressure, etc. One observes, for instance, excessively bright flashes of flame of extremely short duration accompanying the phenomenon known as fuel knock or detonation. The cause for this phenomenon is, of course, not revealed by usual observation.

DEVELOPING STANDARD SPECIFICATIONS FOR PAPER BAGS USED IN CONNECTION WITH CEMENT AND LIME

TECHNOLOGIC Paper No. 187 of the Bureau of Standards has lately been published on this subject and is for sale by the Superintendent of Documents at 5 cents a copy.

The object of the paper is to aid the manufacturers of paper bags in meeting the requirements of the cement and lime industries, particularly in the matter of obtaining a suitable paper for the shipment of these products. It contains information relating to the methods of testing and the apparatus employed in determining the quality of these bags. Samples are obtained from the manufacturers and are suitably identified. They are then subjected to two classes of tests known as ordinary and special tests. The first class consists of the usual tests for paper, while in the second class, tests are employed which are specially appropriate for paper bags.

These include laboratory tests for recording the stresses and strains which the paper undergoes in service, tests to determine the breaking strength when the bag is filled with sand, and tests to determine the strength of the adhesive used in the bags.

The results of all these tests are tabulated and from the data thus secured the best quality of bags is chosen. As a result of this work, specifications have been written covering all the qualifications of satisfactory bags for this service.

MEETING OF EXECUTIVE COMMITTEE OF THE AMERICAN ENGINEERING STANDARDS COMMITTEE

A MEETING of the Executive Committee of the American Engineering Standards Committee, the headquarters of which are at 29 W. 39th Street, New York City, was held at the Bureau of Standards at 10 o'clock on Friday, April 8.

The object of the meeting was to discuss the possibility of securing government support for the valuable work which this committee has in hand. Representatives of the War, Navy, Agriculture, Interior and Commerce Departments were present as well as representatives from the various engineering societies holding memberships in the committee.

COMMITTEE MEETING ON REVISION OF TIRE SPECIFICATIONS

ON April 8 a meeting was held at the Bureau of Standards for the purpose of discussing government tire specifications. The Motor Transport Corps, as a very large user of automobile tires, is particularly interested in this problem, and it assisted by sending announcements of the meeting to various tire manufacturers. Representatives of the different companies were particularly requested to be present and in addition the Government was represented as follows: War, Navy, Treasury, Agriculture, Interior, Commerce, and Post Office Departments, the Panama Canal, Shipping Board, Compensation Commission, and the Commissioners of the District of Columbia.

At the meeting ways and means for revising government tire specifications, with the view to adopting better standards, were discussed. Specifications for tires which the Bureau had prepared were submitted to the committee for discussion and the various members suggested such changes as seemed desirable. The committee decided to send a copy of the specifications, together with these recommended changes, to the Rubber Association of America for their consideration and possible further revision. The specifications and the resulting changes are then to be returned to the Bureau of Standards when a second meeting will be called for further consideration of the problem. When completed, these specifications for tires will be available to the various branches of the Government, to municipalities, and to private corporations who buy tires in quantity.

MEETING OF THE ADVISORY COMMITTEE ON NON-FERROUS ALLOYS

THE semi-annual meeting of the Advisory Committee on Non-ferrous Alloys was held at the Bureau on April 20 and was well attended by members of the non-ferrous industries, representatives of the several interested technical societies, and also by representatives from the technical services of the War and Navy Departments. Among the subjects discussed were specifications for hard drawn brass wire for use in connection with the release mechanism of airplane bombs, rotating bands for projectiles, various aircraft problems related to albuminum alloys, bearing metals, the rôle of gases in metals, and the corrosion and etching of metals.

The Committee considered the corrosion problem of the greatest economic importance and thought it desirable to form a joint committee, the organization of which would resemble that of the Joint Committee on the Effect of Sulphur and Phosphorus in Steel, and the Secretary, Mr. Corse, was requested to raise the question at the forthcoming meeting of the Division of Research Extension of the National Research Council.

DISCOLORATION OF INDIANA LIMESTONE

IN order to eliminate the brown stains which frequently appear on new limestone masonry and which are thought to be due to the mortar, tests have been started to determine the effect of using colorless waterproofing materials on the limestone at points where it comes in contact with the mortar. The indications are that if water can be prevented from leeching through the mortar and entering the limestone that stains will not occur. The tests indicate that the greater part of the stain can be prevented by this means.

Another method of eliminating the stains, which is being tried, consists of coating the exposed face of the limestone walls as they are built with a porous coat that can be readily removed. The stains come through the coat and form on the outer surface and by removing the coat the stain is removed also. The insoluble nature of the material which forms the stain makes it very difficult to remove from the limestone, but by allowing it to form on the coating, as mentioned above, it can be readily removed. Since most of these stains form during the erection of the masonry, the method may prove of some value.

NON-FERROUS ETCHING REAGENTS

AN interesting development in connection with the etching of nickel and its alloys is the use of concentrated hydrochloric acid. This appears to be the best reagent for producing contrast without pitting of the surface that has yet been tried. It is rather hard to etch nickel and ordinarily the metal pits considerably and a plain etched pattern, that is, one in which there is no contrast between different grains, is the usual result. Etching in concentrated hydrochloric acid for a considerable period, say one hour or more, gives very satisfactory results.

STRENGTH TESTS OF IDEAL WALLS

AN investigation has been started to determine the compressive strength of Ideal brick walls in coöperation with the Common Brick Manufacturers Association of America. The Ideal walls are laid with common brick but in such a manner as to include an air space in the wall and still be well tied together. There is a considerable saving in the number of bricks, the amount of mortar and the time required to lay these walls over the ordinary solid walls. It is also claimed

that one can plaster directly on these walls thus avoiding the expense of studding, lath, etc. The present schedule calls for the erection of three Ideal walls and two solid ones for comparison. Four of the walls have already been built and will be tested as soon as they are 30 days old. Considerable preliminary work, such as gage calibration and the testing of individual bricks, has already been done.

INVESTIGATION INTO THE CORROSION OF SHEET DURALUMIN

AN inspection has been made of corroded duralumin in the form of thin sheets used in the construction of all metal airplanes. The material became brittle in service owing to the development of intercrystalline "cracks" evidently as a result of corrosion.

The attemput was made to produce the brittle condition in portions of the sheet which apparently were still ductile. By corrosion alone as well as by the simultaneous action of corrosion and stress, it was possible to develop intercrystalline brittleness in the specimens.

Annealing of the material, annealing followed by slight cold rolling and severe cold rolling of the commercial stock did not appear to affect the corrosion materially. In this case it appears certain that the deterioration was the result of the corrosion of the sheet. Brittleness developed because of corrosion from both acid and neutral solutions but an alkaline attack did not appear to cause the development of brittleness.

Notes on Science in America

Abstracts of Current Literature

Prepared by Edward G. Spaulding, Ph.D., L.L.D., Professor of Philosophy, Princeton University

MINIMUM SOUND ENERGY FOR AUDITION

EXPERIMENTS have been made by several different observers to determine the minimum sound energy required for audition, and the variation of the sensitivity of the ear with frequency. The results obtained vary over a considerable range, the values given by Wien (Archiv. für die gesammte Physiologie, V. 97, 1903) showing a much greater sensitivity of the ear and a much greater variation of this sensitivity with frequency than those obtained by Rayleigh (*Phil. Mag.*, V. 38, 1894), Zwaardemaker and Quix (Archiv. für Anat. und Physiol., Supplement, 1902) and others.

A new demonstration of the ear sensitivity seemed desirable and this was undertaken with a thermo-phone as the source of sound, this being a thin metal strip heated by an electric current. The theory of the thermo-phone has been worked out by Arnold and Crandall (*Phys. Rec.*, V. 10, 1917), and a quantitative expression given for the sound energy produced in terms of the electrical input and the constants of the metal strip. In the present experiment, the thermo-phone element was placed in a small telephone receiver case and held tightly to the ear. The other ear was closed by a dummy head receiver and the experiment was conducted in a padded room, so that external noises were eliminated entirely. A second person opened and closed the electric circuit with a knife switch, and the input was reduced in small steps until the observer became uncertain in his judgments as to when the switch was opened and closed, these judgments being indicated by a movement of a finger. The alternating input was measured with a thermocouple and a micro-ammeter. A direct current of one ampere was used in the thermo-phone, which was of platinum, 0.000216 cm. thick. Six frequencies were used, covering the range from 128 to 4096 p.p.s. in intervals of an octave, a vacuum tube oscillator furnishing the alternating currents from which the harmonics were eliminated by means of electrical filters.

The results showed a wide difference in sensitivity for different ears, observations being made on eight ears. Some of the ears showed as great a variation of sensitivity with frequency as is indicated by Wien's data, the energy necessary for audition at 128 p.p.s. being 100,000 times that required at 2048 p.p.s. The smallest rate of energy flow necessary in any observation was about 10,000 times the minimum found by Wien, and was 2.2×10^{-8} ergs per square centimeter per second, the frequency being 2048 p.p.s. The corresponding particle displacement is 0.025 $\mu\mu$.—Abstract from article by F. W. Kranz, *Physical Review*, March, 1921.

VULCANISM AND MOUNTAIN-MAKING

IN an interesting article in *The Journal of Geology* for February-March, 1921, Dr. R. T. Chamberlin discusses Vulcanism and Mountain-Making. Many folded mountain ranges of both thin-shelled and thick-shelled types, says the author, are characterized by cores of crystalline rock, in considerable part of igneous origin. In many of these the crystalline rock clearly belongs to an old terrane arched up in the folding process and exposed by erosion; but in many other cases the intrusive relations of the igneous rock have led to the belief that it was intruded into the axis of the folded range in a late stage of the arching process. The wide prevalence of this phenomenon has been emphasized by Daly.

Comparing the two types Dr. Chamberlin says that in those thin-shelled ranges in which overthrust faulting has been a dominant feature, intrusions formed in this way should not be conspicuous in the marginal portions where the phenomena of overthrusting are best displayed and the shell was thinnest, but rather in the heart of the deformed belt, where the shell involved in the diatrophism went somewhat deeper and lifting was relatively more important. As an example of this, the author cites the following:

In the Scottish Highlands on the western border the planes of overthrusting dip eastward under the deformed belt; in Scandinavia they dip westward likewise beneath the strongly deformed belt. Together, Scottish thrusts on the west and Scandinavian thrusts on the east, they constitute seemingly a wedge similar to the Appalachian wedge of Pennsylvania.

The outer marginal portions of ranges of this type, both folded and faulted, he says, are particularly superficial. In the great overthrusts but very shallow flakes have been moved. The very low inclination of the fault planes does not carry them to great depths. Beneath the planes of overthrusting, the underlying strata, if of incompetent material, are found to be contorted in many places, but this folding rapidly dies out away from the thrust planes. Such shallow deformation does not greatly facilitate the movement of magmas. But back in the heart of the deformed belt the disturbance goes much deeper, and uplifting with relief of pressure beneath is more pronounced.

The thick-shelled mountains, on the other hand, Dr. Chamberlin says, have been characterized by open, gentle folding, moderate crustal shortening affecting a deeper zone, by strong uplifting, and the extravasation of much lava. Vertical diastrophism seems to dominate over horizontal. Normal faulting is an important accompaniment, occurring either incidentally as a part of the uplifting process or as a result of subsequent relaxational movements of the raised plateau-like area. Iddings has given an excellent exposition of the part block faulting has played in the extravasation of lava. According to his belief, block faulting under tensile stress offers the principal outlets for the escape of lava. To quote: "The deepest fractures starting from the zone of potential magma should

permit its eruption and intrusion between blocks that tend to part from one another by reason of the tensile stress." The wide prevalence of normal faulting in mountains of the thick-shelled type should therefore be an important factor in the rise of magmas. The steep inclination of normal fault planes carries these fractures to greater depths than the more gently inclined thrust faults. At the same time normal fault planes because of the governing tensile-stress, at least locally, become the more ready avenues of escape for the lavas. While rhyolite and other acidic lavas have appeared in vast quantities in some places, andesitic and basaltic lavas appear to have been, on the whole, more abundant. This may perhaps be in part because the greater liquidity of the basic lavas makes migration along narrow fissures easier for them than for the more viscous silicic magmas.

In conclusion, Dr. Chamberlin says that the formation of thick-shelled mountains is characterized in general by much volcanic activity. There may also be important intrusives bearing a close relation to the mountain-making stresses. The growth of thin-shelled mountains, in contrast, is accompanied by very little volcanic activity, at least within the truly mountainous belt. Little igneous activity of any sort is manifested in the marginal and most strongly overthrust portions of thin-shelled ranges; but in the heart of the deformed belts, where there has been more uplifting and the affected zone goes deeper, granitic and other intrusions are a common and probably characteristic feature. It is, of course, also to be recognized that a region which, in an earlier age, has undergone deformation of the thin-shelled type may, in a later age, after long continued denudation, participate in orogenic movements of the thick-shelled type and so become the scene of volcanic activity on a large scale.

THE MEASUREMENT OF SEA WATER SALINITY

IN the *Journal* of the Washington Academy of Sciences for April 4th, 1921, Mr. A. L. Thuras discusses the practical application of the electrical conductivity method of measuring sea water salinity.

Heretofore the only reliable method of measuring the total salt content of sea water has been by chemically titrating for the amount of chlorine present. The relation of chlorine to the total salts being a constant, a measure of the salinity is thereby obtained. Salinity is defined as the number of grams of total salts in 1,000 grams of sea water. The titration method, being a laboratory method, requires that the samples after collection be stored in suitable bottles until they can be tested on shore. The disadvantages of such a method are: The loss or breakage of samples, possible errors from evaporation and handling, and the great undesirability of not knowing the physical properties of the waters while they are being investigated.

During the Ice Patrol of 1920 an opportunity was given to use the electrical method of measuring sea water salinity on board ship. An apparatus consisting of instruments and parts secured from the Bureau of Standards was set up on shipboard and several hundred determinations of salinity were made. The operation of the apparatus was simple and convenient and at no time did weather conditions interfere with the measurements. This apparatus consisted of: A wheatstone bridge, a Leeds and Northrup alternating current galvanometer, a specially constructed electrolytic cell designed for a salinity recorder, a hand regulated temperature bath, and a rebuilt 1/12 horse-power direct current moter to give 120 volts, 60 cycles of alternating current when connected to 110 volts direct current.

All measurements were made 25° C. and a table was prepared to give salinities directly from the balanced bridge readings. The complete apparatus was tested each day by standard sea water taken from a supply which had been carefully measured both by a chemical method and a density method before beginning the cruises. This supply of sea water lasted throughout the cruises. The temperature of the electrolytic cell bath could easily be held to within 0.03° C., and the bridge, after balancing the moving coil of the galvanometer so that the center of mass was fairly near the axis of support, could be set to a value corresponding to 0.02 in salinity. No electrical capacity or inductance was necessary for balancing the bridge, and variations in the voltage and frequency of the generator had no appreciable effect on the bridge setting. With the apparatus used the determinations were accurate to 0.05 in salinity, or better than 0.02 of one per cent.

HEIGHT, HYGIENE AND PHYSICAL TRAINING

DR. CLELIA DUEL MOSHER, of Stanford University, finds through the study of 4,023 women who have entered the university during the past thirty years statistical evidence that American women are increasing in size. Through a careful study of the measurements of these women at the time that they entered the university, Dr. Mosher draws the conclusion that the height of the average woman has increased between an inch and an inch and one-tenth during this period.

Dr. Mosher, also from the same statistics, concludes that there has been a noticeable increase in the average weight of American women.

This physical improvement in the average American girl Dr. Mosher ascribes mainly to two factors: The change in fashion, causing women to wear clothing which interferes less with hygiene, and the increased physical activity among women, which has been brought about by this change in dress and by the development of physical training and sports in schools and colleges and the change in the conventional attitude toward these activities for women.

Since these measurements were all taken of girls at the time they entered college, the increases are indicative of a general improvement among women and are not due to the benefits received from physical education in the university. Furthermore, the improvement noted is not confined to California women or even to western women, but apparently is applicable to all American women. The students whose measurements have been studied and compared over thirty years came from all parts of the country, and Dr. Mosher has compared the measurements of California girls with those of girls from other parts of the country for fourteen of the thirty years and finds that the curves showing increase in height and weight over this period are upward for both classes.

Another element which still further emphasizes the improvement shown is the fact that the age at which girls enter Stanford has decreased during the thirty years so that the women who have shown gains in height and weight during the latter portion of this period are, in addition, younger than those who were measured during the earlier years. This decrease in age is likewise true of both Californians and non-Californians.—Abstract from *School and Society* for March 26th, 1921.

A NEW PHYSICAL TEST FOR A MAN

IN *School and Society* for January 29th, 1921, Dr. D. A. Sargent of Harvard University gives an account of a new "physical test for a man."

In popular estimation, says Dr. Sargent, it takes so many inches and so many pounds and a certain size of chest girth to make a man, and this estimation is borne out largely by experience.

Such measurements alone do not tell us, however, anything of the texture and quality of the parts covered, *i.e.*, how much is fat or bone, and how much muscle, nor do the measurements alone give us any information of the innervation of the parts upon which power and efficiency so frequently depend. Even if we accept the physical measurements of a man as an indication of his potential power, as so many of us almost intuitively do, we are soon taught by experience that there is in many men an unknown equation which makes for power and efficiency which has never been determined and which can only be measured by an actual test.

The important question is, what is this unknown equation and how can it be simply and practically tested and numer-

ically expressed? With a good many others Dr. Sargent has been wrestling with this problem for years by the way of strength tests, endurance tests, speed tests, etc., but without coming across any one method that was perfectly satisfactory.

Dr. Sargent then describes what he has found to be the simplest and most effective of all tests of physical ability. The individual to be tested stands under a cardboard disk, or paper box cover, heavy and stiff enough to hold its form, about twelve inches in diameter, held or suspended from ten to twenty or more inches above his head. He is then requested to bend forward, flexing the trunk, knees and ankles, and then by powerful jump upward, straightening the legs and spine, to try to touch the cardboard disk with the top of the head. Swing the bent arms forward and upward at the same time the legs, back and neck are extended, will be found to add to the height of the jump. When the disk has been placed at the highest point above the head that can be just touched in jumping, this height is measured. The difference between this height and that of the total stature is of course the height actually jumped.

Now, if this height is multiplied into the total weight of the body at the time of making the jump, it will give one some idea of the amount of work done in *foot pounds* as usually calculated. But it will be observed, no credit is given for lifting the full weight of the body from the deep knee or squatting position to the perpendicular position, which difference represents about half the height. The total work depends upon how heavy and how tall the individual is. Thus, if a man weigh 150 lbs. and is 70 inches tall, one half of that height would be 35 in., which, multiplied into the full weight and divided by 12 inches would equal 437 foot-pounds, thus:

$$\text{Formula A} = \frac{\text{Weight} \times \text{Half the Height}}{12} = 437 \text{ F.P.}$$

In estimating work done outside of the body, this amount of energy expended is not always taken into consideration as power expended. In the new test, however, an individual must not only do a certain amount of work in physical effort in rising from the crouching attitude to the perpendicular position but he must generate force enough to project his body 10, 20 or 30 inches in the air, above the height attained in the standing position. If this person weighing 150 pounds should jump 20 in. above his height, this weight multiplied by 20 and divided by 12 would equal 250 F.P. thus:

$$\text{Formula B} = \frac{\text{Weight} \times \text{Height Jumped}}{12} = 250 \text{ F.P.}$$

This amount of work done would be acceptable according to the usual methods of estimating man power. Both the A and B formulæ are frequently used for tests of the physical basis of efficiency. The height jumped will depend a good deal upon the length of the legs and trunk that make up the total stature, the tall man being favored—therefore an exact ratio of the height jumped to the stature would seem to make the test more equitable. Thus, if the man weighing 150 lbs. was 70 in. tall and jumped 20 in. above his head, the ratio of 20 to 70 would account for this advantage in height. This ratio may be obtained by the following formula:

$$\text{Formula C} = \frac{\text{Height Jumped} \times 100}{\text{Total Height}} = .285$$

Although the formulae A, B and C are interesting in enabling one to account for his efficiency or deficiency in the test, these formulæ may be dispensed with in favor of one including the three important factors under consideration. If then in the new test we multiply the total weight by the height jumped and divide this product by the total height of the person in inches the result will give a fair index of the effort made in the smallest number of figures.

Thus if the individual tested weighed 150 lbs. and jumped 20 in. above his head and was 70 in. tall, the formula for his efficiency index would be as follows:

$$\text{Index} = \frac{\text{Weight} \times \text{Jump}}{\text{Height or Stature}} = \frac{150 \times 20}{70} = 42.8$$

Dr. Sargent gives tabular results of trying out his test, and concludes that the test as a whole may be considered as a momentary try-out of strength, speed, energy and dexterity combined, and one that furnishes a fair physical test of a man, solving in a simple way the unknown equation as determined potentially by height and weight.

AN AMMONIA GAS PROBLEM AND ITS SOLUTION

RESEARCH does not always involve tedious experimentation. When helpful knowledge of former research is available, and men coöperate, problems are sometimes quickly solved. The solution of a problem for one purpose may be useful in many others, if properly recorded. The technical and scientific societies and journals and our libraries can be helpful, if utilized; also the Research Information Service of the National Research Council.

Ammonia in some forms is, with impunity, used daily for many household purposes, but ammonia gas in quantity is deadly. Nevertheless, this gas is extensively employed for refrigerating and other processes. It may be safely used, if rightly controlled. Some years ago many fatal accidents occurred due to safety valves on ammonia pipes discharging the gas into the operating rooms of refrigerating plants, hotels and manufacturing establishments. As a consequence, Massachusetts and New York passed laws requiring safety valves to have a discharge pipe through the roof to extend ten feet above the roof, if the adjoining building were higher.

In New York one of the first problems encountered under the new law was the piping in the many-storied Woolworth Building on lower Broadway. There were but few data available by which the size of the ammonia discharge pipe could be figured, because little was known about the difference of pressure required to put a given quantity of super-heated ammonia gas through a long pipe, the pipe being open to the air at one end. Experiments were then made to deduce a formula for the flow of ammonia gas in a pipe open to the air. What quantity would flow through a pipe of given length and diameter, under a given pressure at the entrance end of the pipe? Similar experiments were made on the discharge of steam. From these data it became evident that a 2-inch safety valve had to have a 6-inch pipe to discharge, even with 5 pounds pressure above the atmosphere at the entrance of the pipe, the quantity of ammonia gas that would pass through the 2-inch safety valve.

The old idea then came into the minds of two engineers working on the problem, that the flow of steam from 275 pounds absolute pressure into the air was practically the same in quantity as the flow of steam at 275 pounds absolute pressure into a chamber where the pressure was 150 pounds absolute. This led to the design of an ammonia safety valve discharging against back pressure. The question was: What was the upper limit of back pressure that an ammonia valve could discharge against?

Other series of tests were made to determine this minimum pressure. It was found that the flow into a reservoir where the back pressure was 0.585 times the entrance pressure (that is, somewhat more than half the entrance pressure) was exactly the same as the flow into a reservoir where the pressure was atmospheric. As a result, a safety valve was designed which would discharge against back pressure. Tests on this valve showed that the theory was correct. Ammonia safety valves as built today are made in such a way that they are capable of discharging against this high back pressure.

This, of course, means that the discharge pipe in cases like that mentioned, instead of being six inches in diameter, can be of a very much smaller size, since the entrance pressure in this pipe is now approximately 150 pounds instead of five pounds above the atmosphere. The resulting economy and convenience are obvious, as well as the satisfactory solution of this detail problem in the safe use of ammonia gas.—Information furnished by Prof. Edward F. Miller, Massachusetts Institute of Technology, Cambridge, and here published by courtesy of the Engineering Foundation.

Science and National Progress

Edited by a Committee of the National Research Council

Dr. Vernon Kellogg, Chairman, Dr. R. M. Yerkes, H. E. Howe

RECENT WORK OF THE RUSSIAN ACADEMY OF SCIENCE*

By Sergius Oldenburg,
Permanent Secretary

The following article giving an interesting account of the persistence of activity on the part of the Russian Academy of Science in the face of great obstacles, appeared recently in the Russian daily newspaper "Novy Poot" (The New Path), published in Riga.—Editor.

The National Research Council is a cooperative organization of the scientific men of America. It is established under the auspices of the National Academy of Sciences and its membership is largely composed of appointed representatives of the major scientific and technical societies of the country. Its purposes are the promotion of scientific research and of the application and dissemination of scientific knowledge for the benefit of the national strength and well-being.

Very recently I have had an example of the surprising degree of isolation which segregates the peoples of Europe from each other in these days in spite of their geographical proximity. Word has come to me from Sweden that scientists there believe that "the famous Russian Academy of Sciences is destroyed" and that our "museums and libraries are in ruins." My colleagues Grabar and Vinogradov have already presented the status of Russian museums and libraries. I would like to speak about the work of the Academy of Sciences. During the nearly 200 years of its existence the Academy has lived up to the idea of its great founder, Peter the Great, to foster creative thought and to stimulate the application of scientific achievements to practical life; this was true in the 18th and 19th centuries and it is still more clearly evinced in the 20th century. Lately the Academy has been in a position to cluster about itself some 600 scientific men working in its laboratories, museums, libraries and on numerous commissions. One of the greatest difficulties which confront the scientist in Russia is the almost absolute impossibility of publishing scientific work. However, through great effort the Academy jointly with its principal Commission for the Investigation of the Natural Resources of Russia succeeded in publishing in 1920 nearly 500 signatures[1] *i.e.*, about 8,000 printed pages.

The publication of scientific work really constitutes the foremost problem of today, since the Academy of Sciences alone has in manuscript form nearly 4,000 signatures (64,000 printed pages) which are ready for the printer, but cannot be published. This matter was properly presented by the Academy to the Council of People's Commissars by whom it was given special attention. Among the papers published may be mentioned a series of contributions to a voluminous work on the "Natural Resources of Russia," in which very complete data on this subject are being brought together—an especially important work just at this time when we must have an inventory of the natural resources which constitute our economic basis. Detailed monographs on separate topics, such as those on sizing clays, fire-resisting materials, building materials, tea, tobacco, medicinal herbs, etc., are being issued along with this large set.

Among the other publications we may name the *Russian Journal of History*, and the work of Academician Shakhmatov, deceased in 1920, on "The Ancient Destinies of the Russian Race." Over 1,000 pages of the Academy's "Proceedings" were published containing a series of articles on various subjects, mainly on mathematical and natural sciences.

If only our print shops would commence to work at more normal speed, we would have plenty of material for scientific papers, accumulated and accumulating.

We should now note a very important tendency in contemporaneous Russian scientific work. I speak only of the Russian work known to me, but I believe that an analogous situation exists also in the West. We are now inclined to sum up definitely the work of the past, to make clear the existing working hypotheses and the confines of our scientific achievements. This is quite necessary for economization and organization in scientific work. A certain crisis in science, a necessity for finding new paths, has indeed been felt for a number of years; we have been collecting an enormous amount of material not being quite certain whether we do it properly and whether we gather the most necessary data and withal we have felt the inadequacy of our methods of work and the defects of our organization.

The war suddenly diminished the opportunities for collecting new data and thus naturally forced us to turn to theoretical studies and also created the need of summations.

As an illustration of such summations we have mentioned the conspectus of the Academy's Commission on Natural Resources of Russia. We may also point to a joint undertaking of the same commission in collaboration with another academic Commission for the Study of the Racial Composition of the Population of Russia. Funds for this work are given by the Supreme Council of National Economy.

A regional description of Russia is in preparation under the editorship of Academician Fresman. Russia is being divided into regions mainly on the basis of geographical and economic principles. There is to be a comprehensive account, beginning with the geographical description of the country, followed by data regarding its inorganic and organic wealth and ending with the people and their productive activity. Nearly 100 signatures are ready for print and conferences are being held relative to the commencement of the publication of the entire series with colored charts and plates. The same Commission has published the first issue of a series entitled "The Wealth of Russia."

The Commission for the study of the racial make-up of Russia has issued a racial map of Bessarabia prepared by Professor Berg, and two numbers of "Essays on Classification of the Population of Caucasus" by Academician Marr, and "The Talishes" by Marr and B. V. Miller. Besides, there are ready for print issues on the Tarangs (emigrants from eastern Turkestan) in Semirechye, on the mountaineer Tadjiks in Pamir and several issues on the racial composition of the population of a series of provinces in the Volga region and in Central and Northern Russia, also a series of papers on separate tribes of Siberia. The last edition of the racial map of White Russia with an explanatory text by Academician Karski is now entirely exhausted; this map had three editions and there is now in preparation a revision in greater detail.

The two above-mentioned academic commissions, especially the Commission for the Investigation of the Natural Resources of Russia, have engaged a large number of workers. More-

*Translated from the Russian by Michael Shapovalov, of Washington, D. C.

[1]Signature is a printer's term, designating 16 pages.

over, they are collaborating with the Russian Geographic Society which is preparing a large geographical dictionary of Russia, and with the Geographic Institute in compiling a detailed and comprehensive description of the Petersburg province, also with the Academy of the History of Material Culture which is conducting a series of ethnological investigations and inquiries. In addition, the commission on natural resources works in the domain of geology in close union with the Geological Committee and in the domain of hydrology with the Hydrological Institute, an offshoot from the Commission like many other institutes; optical, ceramic and others.

Among the voluminous collateral undertakings carried on by the Academy should be mentioned the "Fauna of Russia" issued with the intimate assistance of the Zoological museum of which 20 volumes have already been published. It is to be regretted that the typographic derangement prevents further publication of this important synthetic work. The same fate has overcome another manuscript of the Academy, "Flora of Siberia," of which only one number has appeared in the current year, although as with the "Fauna of Russia" abundant material is ready for the printer. The Zoological and Botanical Museums are working diligently on these undertakings.

Following the heavy losses suffered by the Academy in the death of Academicians Lappo-Danilevski, Dyakonov and Shakhmatov, the permanent historic commission, upon electing Academician S. F. Platonov as its chairman, again resumed its work and expects to issue the first volume of a "Collection of Edicts of the Collegium of Economy" which has long been awaited by the Russian historians and which is of so great economic importance. Along with this the commission expects to resume certain other of its investigations, particularly since it is now known that the scientific correspondent of the historico-philosophical section at Rome, though in very straitened material circumstances, continued his work without interruption. It is to be hoped that the communication with him may improve. Besides, the permanent historic commission has been instructed to look into the possibilities of uniting at the Academy all archaeographical work in general, since it is especially desirable to organize now because of the existence of the Glavarchiv consolidating all Russian archives.

The museums of the Academy being deprived of the opportunity to send expeditions because of present world conditions are engaged in the task of revising collections, a work of prime importance for every museum, but one which can scarcely be done adequately under normal conditions. Some museums, however, such as the mineralogical and ethnographical, in spite of the absence of expeditions, have received extensive entries from private collections. The ethnographical museum in its annual report complains that hundreds of boxes of valuable collections made during a number of years by the collaborators of the museum, Marvardts in India and Shirokogorov in Manchuria, remain unmoved awaiting transportation.

The library of the Academy and the Academy's House of Pushkin, which has accumulated a vast library of new literature, have been enriched by very remarkable collections. The very rich Vorontsov collection of manuscripts, the library of Longinov, and a whole series of archives of writers and their separate manuscripts have been placed in the Academy. It is much to be desired that the new library building already occupied too long by various temporary hospitals may soon be returned to the Academy, as otherwise it will remain impossible to make use of hundreds of thousands of new entries.

It is obvious that a many-sided and broad activity cannot be exhaustively reviewed in a single brief newspaper article. I may state here that the annual report on the work of the Academy and its institutions, concerned merely with the enumeration of facts, comprises a volume of over 400 pages. I wished only to emphasize certain phases of the Academy's work and thus to show that the Russian Academy of Sciences of which Russia may justly be proud and which soon will complete two centuries of its existence, is not only not destroyed, but is working diligently. It is true that the conditions of labor are hard; we have no new western books which are so urgently needed; we feel a great want of material for scientific work, often it is very cold in winter in working quarters, the supplies of electricity and gas are insufficient, frequently the scientist lives in cold and hunger. All this is so and we do not deny it, but nevertheless the work is in progress, work genuine and fruitful, of course far less intensive than it might be under better conditions of living, but nevertheless, I repeat, it is genuine work. Those who remain to work in Russia believe in Russian science, in the Russian people, and in their duty to Russia and to its great culture, the duty to work as long as strength lasts, to work not in fear, but in fidelity.

Breaks in our cultural work must not be and we firmly believe that, in spite of whatever hardships may befall the Russian scientists by virtue of all that is now going on throughout the whole world, there shall be no break and we, the passing old generation, shall turn over the work to the worthy rising generation of Russian scientists together with our last will and testament—work so long as ye live!

PAPER MAKING MATERIALS

DR. C. J. WEST has compiled a reading list of paper making materials which has been reprinted from the *Paper Trade Journal* and which can be recommended to all those concerned with the subject. The evaluation of paper making material is given in the following quotation from William Raitt of India:

"1. It must have no value for any other economic purpose, either to the spinner, rope maker, or to any exclusive extent at least, to the feeder of cattle.

"2. It must be a free gift of nature, of spontaneous self-sown growth, capable of natural reproduction, and not liable to exhaustion under a reasonable system of cropping.

"3. It must mature annually, or at periods not exceeding three years, so that a pulp factory can obtain supplies from the area surrounding it in perpetuum.

"4. No fiber requiring cultivation is admissible. This does not of course apply to fibrous material obtained as a by-product, *e.g.*, straw as a waste from grain cultivation.

"5. No material requiring manual or mechanical manipulation for the separation of the fiber from the body of the plant is admissible, the cost of such separation being prohibitive, and such fibers being invariably of greater value to the spinner.

"6. Its habit must be gregarious and in sufficient local abundance to bring cost of cutting and collection within economic limits, a plant which grows in tufts or patches at long distances apart not being admissible.

"7. It must contain at least 30 per cent of cellulose. This is an item which may vary in accordance with the local cost of other factors, but I think it is safe to assume that under no conditions will a yield of less than 30 per cent pay.

"8. The total quantity available within economic collecting radius of a mill site must be sufficient to produce at least 2,500 tons of pulp annually. This is also a figure which must vary in accordance with the cost of other factors. Generally it will be much higher. I place it at that, because there are locations where the other conditions are so favorable that even this quantity will pay, and because it is doubtful whether any local advantages could bring a smaller quantity to a profitable basis.

"9. No material is admissible which does not grow in a locality possessing cheap labor, and water for manufacturing uses.

"10. And it must grow within economic range of power, lime, and transport to seaport."

Reading lists of this type represent a tremendous amount of tedious work and it is hoped that full use will be made of results obtained.

Progress in the Field of Applied Chemistry

Notes Culled from Current Technical Literature

By H. E. Howe, Member of American Chemical Society

AT THE SILK EXPOSITION

"One of the most interesting features of the Japanese Exhibit at the recent Silk Exposition, New York, was an actual representation of the amount of silk required for the production of a silk dress and jacket of average size. These garments require in their manufacture one and one-quarter pounds of raw silk, which is obtained by the reeling of 1,800 cocoons. As a matter of fact, 2,000 cocoons are required, but there is always a certain loss which reduces the number of unpierced or sound cocoons for reeling the best chops. These 1,800 cocoons weigh four pounds. The 2,000 silk worms that produce these cocoons require for their food 125 pounds of mulberry leaves. It is said that when the silk worms, in large numbers, are feeding on the leaves, the sound one hears closely resembles that of falling raindrops.

"Incidentally, the relatively small amount of silk required in a silk dress, as shown above, may throw some light on the amount of dye required to color it. As a rule, medium shades on silk do not require more than two or three per cent of the dye. There being 20 ounces of silk in a medium weight dress, the amount of dye used for coloring it is considerably less than one ounce, which at the average prices for silk dyes makes the dye cost not more than twenty-five cents."

CHEMICAL MONOGRAPHS

By arrangement with the Interallied Conference of Pure and Applied Chemistry which met at London and Brussels in July, 1919, the American Chemical Society was to undertake the production and publication of scientific and technologic monographs on technical subjects.

"Two rather distinct purposes are to be served by these monographs. The first purpose, whose fulfilment will probably render to chemists in general the most important service, is to present the knowledge available upon the chosen topic in a readable form, intelligible to those whose activities may be in a wholly different line. Many chemists fail to realize how closely their investigations may be connected with other work which on the surface appears far afield from their own. These monographs will enable such men to form closer contact with the work of chemists in other lines of research. The second purpose is to promote research in the branch of science covered by the monograph, by furnishing a well digested survey of the progress already made in that field and by pointing out directions in which investigation needs to be extended. To facilitate the attainment of this purpose, it is intended to include extended references to the literature, which will enable anyone interested to follow up the subject in more detail. If the literature is so voluminous that a complete bibliography is impracticable, a critical selection will be made of those papers which are most important."

Thus far the following monographs have been secured and are now in progress of being written or printed:

The Animal as a Converter.
Chemical Effects of Alpha Particles and Electrons.
The Chemistry of Enzyme Actions.
The Properties of Electrically Conducting Systems.
Carotinoids and Related Pigments: The Chromolipins.
Thyroxin.
The properties of Silica and the Silicates.
Organic Mercury Compounds.
Coal Carbonization.
The Corrosion of Alloys.
Industrial Hydrogen.
The Vitamines.

A NEW ACHIEVEMENT IN AMERICAN DYES

In in its March issue *The Color Trade Journal* makes some observations upon recent achievements in American dye manufacture from which the following extracts are quoted:

"A new dyestuff of remarkable value to the industry has been recently added to the list of achievements of the American dye chemist. This product is Indophen Blue now made on a large scale. . . . It is a sulfur dye of remarkable clearness and brightness of tone, far surpassing in this respect even the German pre-war dyes of the same general type, such as Immedial Indone. It is also remarkable for its high tinctorial strength, which is far greater than any sulfur blues hitherto or at present on the market. But its color value would be of little avail were it not for the fact that the dyeings on cotton obtained with Indophen Blue have a fastness to light, washing and rubbing that is superior even to indigo, while the fastness to alkali, acid, fulling and boiling is equal in every respect to indigo.

"Indophen Blue is considerably brighter than vat dyed indigo blue and more violet in tone; it approximates more closely in fact to the brighter and redder brom-indigo. On account of its great fastness it is of especial interest, and this feature brings it into the same category as indigo. The simplicity of its method of dyeing, however, will make it more broadly available to the dyeing trade than indigo, as the latter requires a specially prepared hydrosulfite vat and a technique which limits its use to a special coterie of indigo dyers.

"Blue is the great staple color of the dyer in all parts of the world, and more blue color is dyed (with the exception of black) than all the other colors put together. Indigo has always been the great staple dye to be used for the dyeing of blue on account of its beauty and fastness. It requires, however, a complicated process of dyeing and cannot be applied like the usual run of ordinary dyes; consequently it is not available to the average dyer. Previous to the war the great German dye factories sought to produce a sulfur color which would take the place of indigo and still possess similar properties of fastness. A number of sulfur blues came on the market, but most of these were dull in appearance, were weak in tinctorial strength, and were expensive as compared with indigo. It is true there were very bright and beautiful blues among the basic dyes and the direct cotton colors, but none of these had the required fastness especially to light and washing, and consequently could not take the place of indigo, though they could be applied to the fiber with great simplicity.

"The advent of Indophen Blue shows that American chemists are equal in ingenuity and resourcefulness to their German competitors, for they have even gone ahead of the latter in producing a sulfur blue, the search for which had long been prosecuted. The German factories were never quite successful in getting out a blue of this type which possessed all the required properties. . . ."

The employment by one of the large dye manufacturers of certain foreign chemists who applied for work has given rise to a considerable discussion. It is worthy of note, therefore, that the employment of these specialists is not in any way a criticism of American achievement or expression of doubt with respect to the ability of American research workers. It is simply a way in which valuable time can be saved, making it possible to combine special and technical skill with the results of American research laboratories. This combination has already resulted in a production of sulfur black, the equal of which the world has not heretofore seen. This dyestuff may be regarded as the first of a series which must result from so favorable a combination as has been secured.

NEW PROCESS FOR MAKING STEEL

FOR the following note relative to a new process developed by a French company for the purpose of manufacturing steel directly from the ore, *Mechanical Engineering* is responsible. A rotary furnace similar to the type employed for making cement is said to be used in the new process:

"In this process the ore is charged at the upper end and works its way toward the lower end as the furnace slowly revolves—at the rate of one revolution in three minutes. Pulverized coal is used for fuel. The air which supports the combustion is previously heated to about 1,000 deg. cent. in a regenerator similar to that connected with an open hearth furnace.

"The temperature of the gases as they leave the furnace is said to be 300 deg. cent. and by the nature of the process these gases contain 44 per cent carbon monoxide. This gas, of course, may be used for heating purposes. The slag is tapped off the top of the metal which is poured into the ingot molds.

"It is stated that three qualities of metal have been produced, including pig iron of a grade between gray and white, hard steel and malleable iron. These results are obtained by varying the ore charge and the temperature of the process."

SIXTY-FIRST MEETING OF THE AMERICAN CHEMICAL SOCIETY

THE sixty-first meeting took place in Rochester, New York, the week of April 25 and proved to be one of the most successful in the Society's history. Over two hundred and eighty papers were presented for discussion before the eleven sections and divisions, in addition to general meetings before which Senator Wadsworth of New York and Congressman Longworth of Ohio made addresses. There was an important symposium on contact catalysis and an interesting discussion on the fuel of the future with particular reference to the part which cellulose and its conversion by chemical methods into fermentable carbon hydrate will play in the solution of the problem. The symposium on drying was held in the industrial division. One interesting observation was made in this discussion relative to the turbulent motion which must be secured in air currents passing through dryers in order to secure uniform drying. In the absence of a turbulent or mixing motion there is a tendency to have formed a layer of moisture, saturated air, which interferes with the further drying of the material. Thus a series of trays may show satisfactory drying on one edge only. This is believed to be due to the fact that the air upon striking such an edge is thrown into motion and drying continues until a saturated layer or quiet air is produced. Air must travel at a greater linear velocity than water to obtain a satisfactory turbulent motion.

With relation to the potash situation, further details were given as to the possibility of obtaining potash from the green sands of New Jersey. There is now under construction a plant capable of treating one thousand tons of green sands per day which will require about nine hundred tons of quick lime which will be produced in the largest lime kiln installation in the country. From these raw materials sixty-five tons of caustic potash will be produced per day and of course other potash salts can be manufactured. Experiments have had to do with the effect of fine grinding upon the reaction, the time and temperature at which treatment must be carried forward, the ratio between the quantities of green sands, quick lime and water which is best for the purpose, and to what extent the reaction can be accelerated by the addition of various salts. When the plant is in working order it will be possible to compete with any sort of potash salt under present day conditions.

That the alcohol situation so far as the chemical industry is concerned is becoming acute was emphasized upon several occasions. The chemist knows alcohol is a solvent which is as important in organic chemistry as is water in inorganic chemistry. Industrial alcohol may be regarded as of equal value with sulfuric acid, nitric acid and the alkalis which are frequently called the foundation stones of chemical industry. The efforts of well meaning people to regulate the consumption of alcohol is tending to have a restricting influence upon industry which is in no way connected with beverage alcohol. A committee of the Society has been appointed to study the situation in the hope that beverage alcohol and industrial alcohol may be separated in the minds of those interested in prohibition.

INDUSTRIAL FELLOWSHIPS

THE eighth annual report of the industrial fellowships of the Mellon Institute, Pittsburgh, has been issued and contains several interesting bits of information including a list of the industrial fellowships in operation at the Institute on May 1, 1921. The diversity of the work will be indicated by a list of the names of the fellowships. These fellowships are endowed from $2,500 to $16,800 per annum. A list of subjects follows:

Synthetic Resins	Emulsion Flavors
Bread	Inks
Illuminating Glass	Cements
Zirconium	Perfumes
Fish Products	Fiber
Fuel	Yeast
Plastics	Silicate
Soap	Magnesia Insulation
Enameling	Coke
Food Container	Organic Synthesis
Synthetic Acids	Insecticides
Protected Metals	By-Products
Stove	Glue
Sulphur	Distillation
Oil-Shale	Fertilizer
Nickel	Dental Products
Corrosion	Cleaning
Flotation	Metal Ware
Duplicator	Laundry
Glass	Refractories
Oil	Asbestos
Quartz	Fruit Beverages
Gas	Magnesia Products
Tar Products	

SOLVENTS PRODUCED BY BACTERIA

IN the March number of *Chemical Age* appears a discussion under this head by H. E. Hall. We are familiar with discussions relative to harnessing Niagara and other great forces of nature but none of us have listed such diminutive things as bacteria among these forces. Solvents are among the most important of reagents used in chemical processes and among the saturated alcohols important as industrial solvents methanol has been about the only one which has refused to be made by fermentation process. Propyl, butyl and amyl alcohols as bacteriological products are recent additions of commercial importance to the list of industrial solvents.

"Among other new solvents which are making their appearance in the industrial field are diacetone alcohol and isopropyl alcohol. The first, like acetone, is a solvent for both the nitrate and acetate of cellulose. There are at least two approved methods of manufacturing this material and its field of usefulness would seem to depend largely upon production costs. With acetone, the principal raw material, available at unusually low prices, it would seem an opportune time to develop the possibilities of diacetone alcohol.

"We are told that isopropyl alcohol can now be produced economically from petroleum. The alcohol being miscible in all proportions with water appears to resemble in properties ethyl alcohol rather more closely than it does butanol or fusel oil. Isopropyl alcohol is not potable and since it possesses valuable solvent properties, its field of usefulness might well cover some of the fields now using denatured ethyl alcohol. The extent to which it will replace denatured alcohol will probably depend largely on the relative prices of these products."

Progress in the Field of Electricity

Summaries and Excerpts from Current Periodicals

By A. Slobod

MOVING PLATFORMS FOR CROSS-TOWN LINES

Some interesting details in regard to the proposed construction and method of electric drive of moving platforms to handle cross-town traffic in 14th, 42nd, and 57th Streets, New York, was recently published in the *Electric Railway Journal*.

The proposed electric corner system of propulsion will permit the use of platforms mounted on car trucks which will effect a material reduction in the cost of construction, operation and maintenance and also of the space required. The distinguishing characteristic of this system is the method of propulsion. The three-phase induction motor of the squirrel-cage type is used. The parts of this motor corresponding to the stationary or primary element are straightened out into sections about 5 feet long and placed midway between the rails in the roadbed, while those corresponding to the revolving element, also straightened out, form a continuous short-circuited secondary mounted on the bottom of the car. The primary elements, when energized with three-phase current by induction, magnetize the short-circuited secondary which extends continuously along the bottom of the car. The result is that the force created between the induced secondary current and the shifting field of the primary propels the car.

The scheme proposed is to use three platforms of various width moving at different speeds. The high-speed platform carries seats for two persons spaced at 3-ft. intervals. As the speed of the different platforms depends on the frequency of the three-phase current applied to the primary, it is clear that any platform may be operated at a lower speed by changing the frequency supplied to it in case it should be desired to shut down one platform and operate the other two, or in the case one platform only is to be operated. The application of this system to the 42nd Street loop would require three platforms, each approximately 10,100 feet long. The seating capacity of the 9-mile platform would be 31,680 passengers per hour in each direction. The weight per seat for all three elements would be roughly 375 pounds while that of a loaded subway train is approximately 1,800 pounds per passenger.

THE DISTRIBUTION OF ELECTRICITY

Two papers appear in the *Journal of the Institution of Electrical Engineers* for January, 1921, dealing with this subject. One was presented by Mr. W. B. Woodhouse; it contains a discussion of the problems involved in organizing a system of distribution as a compound organism from a number of isolated nuclei. The principal conditions of economic distribution are determined by conflicting technical and financial considerations. The author reviews in detail the area of supply involved, the factor of time in relation to capital expenditure, sources of supply, distribution of load, pressures of supply, load factors and losses, networks, high-pressure cables and overhead lines. The following conclusions are reached from a consideration of all the conflicting conditions: (1) Three or more pressure systems are necessary for economy. (2) The detail distribution pressure is fixed by considerations of use; in England a single-phase pressure of from 200 to 250 volts is established. (3) The size of the distributing substations is determined by the density of load and the size of the power users' installations. (4) The distance between these substations depends primarily on the detail distribution pressure; the substations should be as widely spaced as considerations of pressure-drop permit. (5) The main distribution pressure is determined by the number of substations in the area, the total load, and the economical balance between expenditure on mains and on substations. In industrial areas of England a pressure of 10,000 volts has been found economical. (6) The extent of each power distribution network may be reduced with economy as the load develops and the size of substations increases. (7) The transmission pressure is primarily determined by a consideration of pressure-drop and total power, no advantage is gained by exceeding a minimum fixed to meet demands anticipated to arise in a period determined by the rate of growth of load. (8) Main substations are determined in number by the load on the power distribution networks and the pressure of distribution, as well as by the number of generating stations.

The other paper was read by Reginald O. Kapp and dealt with economic aspects of extra high-tension distribution by underground cable. The author points out that, with heavy cost of feeders on modern power schemes, due to the centralization of the generation of electricity in very large power stations, a saving in the capital outlay on the extra high tension distribution system will assume an economic importance comparable with that of reductions in coal consumption. Various means for keeping the cost of the distribution as low as possible without sacrificing safety are discussed.

It is also shown that the position of the power station with reference to its load influences the cost of feeders very greatly indeed and methods of determining its most economical position are given. It is shown that the same methods can be employed to determine the most economical position of the step-down transformer houses.

Rules are given with reference to the design of cable layouts and for determining the most economical voltage of transmission. After an allowance for diversity factor and stand-by cables has been made, the total kva. capacity of feeders leaving a power station is still considerably greater than the maximum station load, on account of uneven sharing of the load; means are suggested for reducing this discrepancy. The author also shows that, on account of the capacity of cables to store heat, their safe continuous rating may be lower than their peak load. The true safe continuous rating is the equivalent continuous load of a daily load curve, and a simple method of finding this is described. The author further discusses the cost of unit electricity as depending to a notable extent on the consumer's load and power factor and, therefore, tariffs devised to encourage an improvement of both are equally to the advantage of supply undertakings and consumers.

The papers are followed by a very extensive discussion.

THE DELETERIOUS EFFECT OF FIBERS ON THE ELECTRIC INSULATING POWER OF OILS

The deleterious effect of water on transformer oil has long been known. Recently attention has been drawn also to the importance of the more complete elimination of other impurities. Of interest in this connection is a series of experiments by Thomas McLaughlin described in *Electrician* (London), for March 18, 1921, pp. 325-327. The author comes to the following conclusions: In dealing with insulating oils great care is necessary to obviate dust particles and fibers, which if present would be liable under the action of an electric field to form up in chains and seriously decrease the insulating power of the oil. Fibers might easily be introduced by using cotton rags in cleaning apparatus. These fibers even though of a very fine and practically invisible nature will have a high conductivity and may easily form a chain for a breakdown by a rush of current and the passage of a spark. The presence of free water particles is also undesirable, for if dust particles

or fibers are present they will join them and render them more conducting, while they may, if very favorably placed, themselves link up and form a chain. If this chain is formed under high voltage it will act as a medium for a spark, the passage of which will release carbon particles which in turn can form a conducting chain.

These results may thus be taken as verifying from a different viewpoint those obtained by previous researches; in particular they seem to point to the truth of the statement that "it may then be positively stated that only a single fiber of poor insulating value will be sufficient to break down the insulation of a transformer, however high the quality of the oil may be as a whole, for the puncture will occur at the weakest point. In so far as a fiber may reduce the specific resistance of an oil hundreds or even thousands of times, it can well be regarded as forming a weak point.

In the course of the research much information as to the electrical properties of liquid paraffin was noted. It seems to be much superior to any other oil as an insulator viewed from the point of view of specific resistance. At about 1,000 volts per cm. its specific resistance was of the order 10^{14} or 10^{15} ohms. Between the parallel plates used a spark in the oil could be obtained at about 2,200 volts per mm.

The *Electrical World* of April 23, 1921, states in an editorial that the experiments mentioned above thus raise the questions whether complete precaution is taken against the passage of fibers into the oil and whether oils should not be examined more rigidly for impurities of this character and whether conductivity tests such as those described in the paper have not some advantages over the usual breakdown tests.

HYDRO-ELECTRIC PROGRESS IN CANADA DURING THE RECENT PAST

J. B. CHALLIS, Director of Water Power, Department of the Interior, Ottawa, contributes a detailed account of Canada's water power development. The total development work completed or under construction in 1920 represented approximately 650,000 hp. of installed capacity. The total developed hydro-electric power in the Dominion now stands at 2,460,000 hp. Taking the population at 9,000,000, the development per 1,000 of population is 274 hp., a figure far ahead of the United States and ahead of any other country in the world except Norway.

The province of Ontario still leads in magnitude of the new developments. In pursuance of the coöperative agreement made in 1919 between the Hydroelectric Power Commission of Ontario and the Department of the Interior, the Dominion Water Power Branch is now responsible for all basic investigation respecting water resources, while the province undertakes the detailed investigation for and construction of actual developments. The total of development under construction in this province amounts to 500,000 hp. The provinces of Nova Scotia and New Brunswick entered on an active policy of provincial government development of their water-power resources. Great activity was shown in organized general hydrometric investigation to meet future requirements and in the investigation and planning of further considerable developments.—*Electrical World*, Vol. 77, pp. 931-934, April 23, 1921. Also *Electrical News*, Vol. 30, pp. 33-36, April 1, 1921.

ELECTRICAL RESISTANCE OF METALS

THE *Physical Review* for February, 1921, publishes a brief summary of an extensive series of measurements which are to be published in detail in the Proceedings of the National Academy, measurements made to determine the effect of pressures up to 12,000 kg. per sq. cm. and of temperatures from 0° to 275° C. on the resistance of lithium, sodium, potassium, gallium, bismuth, mercury, calcium, strontium, magnesium, calcium, titanium, zirconium, arsenic, tungsten, lanthanum, neodymium, carbon-amorphous and graphitic, silicon and black phosphorus. The data for tungsten and magnesium are improvements on data previously published; the data for the other substances are new. The first six of these elements were studied in both the liquid and the solid states. The pressure coefficients of solid calcium, solid strontium, and both solid and liquid lithium are positive, the coefficient of bismuth is positive in the solid state, but negative in the liquid.

A previous theoretical discussion of measurements of the effect of pressure on resistance suggested most strongly that in metallic conduction the electrons pass through the substance of the atoms, and that the mechanism by which resistance is produced is intimately connected with the amplitude of atomic vibration. This view is here given quantitative form. The classical expression for conductivity $= (e^2/2m)\ (nl/v)$ is retained; the number of free electrons is supposed to remain constant, their velocity is taken to be that of a gas particle of the same mass and temperature, and their mean free path is supposed to be many times the distance between atomic centers. The variations of path are then computed in terms of the variations of amplitude, and thus the variations of resistance are obtained and checked with experimental results. It is shown that the theory in this form explains Ohm's law, gives the correct temperature coefficient and the most important part of the pressure coefficient, avoids the difficulty of the classical theory with reference to specific heats, indicates a vanishing resistance at low temperatures, leaving open the possibility of super-conductivity, and retains the classical expression for the Wiedemann-Franz ratio. Besides these quantitative checks the theory is shown to be entirely consistent qualitatively with all the new data; in fact, many of these new results, particularly the effect of pressure and temperature on the relative resistance of solid and liquid, seem to demand this conception of metallic conduction.—P. W. Bridgman, *Physical Review*, Vol. 17, pp. 161-194, February, 1921.

THE LIMITATIONS OF THE STOP WATCH AS A PRECISION INSTRUMENT

IN many scientific and engineering measurements the quantity, time, is an important factor. A high degree of precision can of course be obtained with our present-day astronomical clocks in proper environment and their usefulness extended by electrically relayed circuits. This method, however, is cumbersome, leaves much to be desired and is not generally applicable to laboratory measurements, not to mention the wide variety of field work. The result is the more convenient stop watch, frequently resorted to by engineers.

Mr. A. L. Ellis contributes an illustrated and detailed discussion of the stop watch, its characteristics and errors, costs of various grades, etc., and comes to the following conclusions: Due to inherent errors of timing train and those due to mechanical limitations and design, practically nothing is gained in accuracy by increasing the number of jewels beyond the standard seven-jewel movement. An attempt has been made to reduce the inherent error in at least one instance by increasing the rate of vibration of the balance, but the price at which it was offered was out of all reason considering the accuracy gained and the cost of manufacture. Some of the larger errors do not follow the law of probability, for while the errors may be either plus or minus, and vary somewhat in magnitude, some at least depend upon the interval of time being measured, as for instance, in the case of the Jockey Club type of stop watch; in this case if the interval being measured is less than thirty seconds, the hand will jump forward upon being started again; if the interval is more than thirty-five seconds the hand will jump backward on starting again.

The sources of error in a watch are such that at least two watches should be used simultaneously for timing an event, timing intervals of varying length if possible, the mean of all observations to be taken. The stop watch as applied to engineering measurements is not sufficiently robust for the purpose, and it is to be hoped that manufacturers will make a special effort to produce a stop watch suitable for this class of service.—*Journal of the American Institute of Electrical Engineers*, Vol. 40, pp. 104-112, February, 1921.

Survey of Progress in Mechanical Engineering

Prepared Under the Auspices of the American Society of Mechanical Engineers

AIRCRAFT STATISTICS

THE following preliminary statement of the general results of the 1920 census of manufactures with reference to aircraft has been issued by the Bureau of Census, Department of Commerce, furnishing a detailed statement of the quantities and values of the different types of aircraft manufactured during the year 1919, prepared under the direction of Mr. Eugene F. Hartley, Chief Statistician for Manufactures.

Reports were received from 31 establishments engaged in the industry during 1919 showing products for the year values at $14,372,643, as compared with 16 establishments in 1914 with products valued at $789,872. Of the 31 establishments reporting for the year 1919, ten were located in New York; four in Ohio; two each in California, Massachusetts, and Missouri; and one each in Connecticut, Indiana, Illinois, Louisiana, Maryland, Nebraska, New Jersey, Pennsylvania, Rhode Island, Washington and West Virginia.

The following is a summary of statistics of the industry for 1919, the "All other products" reports consisting chiefly of airplant parts, engines, and repair work:

Number of establishments	31
Total value of products	$14,372,643
Airplanes:	
Number	432
Value	$3,466,452
Seaplanes:	
Number	230
Value	$4,580,016
Value of work done during year on airplanes and seaplanes not completed	1,658,670
All other products, including parts and repair work	4,667,505

COATS STEAM CAR

DESCRIPTION of the new steam car being built at Indianapolis and involving several apparently novel details.

In particular, the engine is located in the rear axle and in fact, the engine axle and differential function all in one, the engine itself in its housing being just about the size of the ordinary rear axle gear case.

The housing of each half of the axle carries three thick cylinders set at 120 deg. apart. These cylinders are exactly like those of the internal-combustion automobile engine with poppet valves, pistons and connecting rods. The bore is 2¾ inches, the stroke is 3 inches. The three connecting rods in each half of the axle are pivoted to a crank pin integral with the drive shaft of each wheel. At a speed of 40 miles per hour the engine is running at about 500 revs. per minute.

The exhaust steam is taken by return pipe to the condenser located in front of the boiler in the position of the ordinary radiator.

The whole engine has therefore six cylinders and the general arrangement is shown in Fig. 1. The car for five passengers completely equipped weighs less than 1,800 pounds and has less than 40 moving parts. It has no carburetor or ignition accessories, no clutch, gear shift, flywheel, propeller shaft, universal joints or differential; uses kerosene as fuel and is claimed to be very economical on that.

It is stated that the design was worked out primarily by a Norwegian engineer, but developed to its present state of refinement in America.—*The Accessory and Garage Journal*, Vol. 10, No. 11, March, 1921, pp. 88-89.

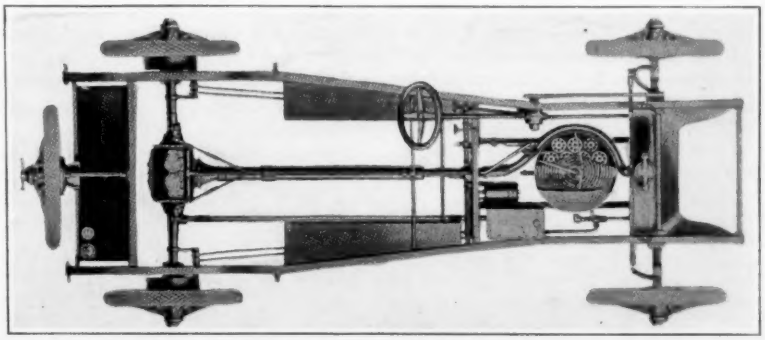


FIG. 1. PLAN VIEW OF THE CHASSIS OF THE COATS CAR

COLUMBIAN FLASK STEAM CONDENSER

DESCRIPTION of a condenser which is said to be extensively used in ice manufacturing plants. The steam enters at the bottom of the head of the condenser into the first or reboiling compartment formed by baffle plates. It travels then the entire length of the condenser ascending into the next compartment, back through the full length of the condenser, again ascending into the next compartment until it reaches the top compartment at the end of which is provided a small opening for the escape of foul or gassy steam, the two in the center being the main condensing compartments.

The distillate travels back over the baffle plates descending to the bottom of the condenser in the same manner in which the steam traveled as it ascended over the baffle plates. This distillate reboils on its way back to the bottom of the condenser and is finally carried off through the distilled water outlet in the bottom of the condenser down into the ice cans below, where it is finally frozen into ice cakes.

The steam entering at the bottom of the condenser is generally from 218 to 220 deg. fahr. with a pressure from ½ to 1 pound. The cooling water which is evenly distributed over the outside of the condenser is usually from 90 to 100 deg. fahr. The hot steam passing back and forth up through the condenser meets the distilled water and reboils it so thoroughly that by the time the distillate reaches the bottom of the condenser in the reboiling chamber, there is no further need of a separate reboiling, yet the temperature in this lower compartment is at about 212 deg. fahr.

Columbian flash condensers are made mostly by hand. The rivets are finished from the inside in order to leave a smooth surface on the outside as a protection against the quick collection of alkalies and minerals that are found in the water. They are usually equipped with a 4-inch steam inlet and 2-inch distilled water outlet, and an additional small outlet in the end of the condenser near the top for the escape of foul steam. —*Refrigeration*, Vol. 28, No. 2, March, 1921, p. 39.

PALM OIL AS ENGINE FUEL

AT a recent meeting of the Association for the Improvement of Colonial Materials, Major Trentals of the Belgian Colonial Army described developments in the use of palm oil and other vegetable oils grown in the Belgian Congo in internal combustion engines.

The tests were carried out on a stationary two-cycle semi-Diesel engine developing 8 to 10 horsepower at 500

r.p.m. The palm oil employed was of medium or low quality containing considerable amounts of free fatty acids and impurities. The only really special feature on the engine was an arrangement made for keeping the palm oil in a sufficiently liquid condition. For this purpose the cylinder cooling oil was used and together with the hot exhaust gases maintained the oil in the feed tank at a temperature high enough to ensure liquidity, and at the same time evaporate any water which might be present. In addition to this a gasoline vapor lamp was placed under the tank.

The feed tank consists of a series of compartments divided from each other by fine mesh metal screens to filter the oil before admitting it to the injection pump.

The engine starts on gasoline and finishes on gasoline in order to remove any residual palm oil from the feed pipes, which might get clogged by the congelation of the oil when the engine is at rest. [The average melting point of oil is about 37 deg. cent. (98 deg. fahr.) which varies with purity and origin.]

A certain amount of water is injected into the cylinder. The palm oil referred to in this paper is obtained from the fleshy pericarp of the palm fruit and not palm kernel oil contained in the palm nut. Palm kernel oil does not differ much in heat value from peanut oil.—Paper before the Association pour le Perfectionnement du Matérial Colonial. — Abstracted through *Gas and Oil Power*, Vol. 16, No. 186, March 3, 1921, pp. 85-86.

THE SPRENGER PROCESS OF MAKING CONCRETE

By E. Weiss

In this process a machine is used which its inventor calls Aero-Malaxeur. The principle of this machine consists in projecting wet sand and gravel through an atmosphere saturated with the binding material which may be blown in in the state of complete pulverization by some kind of a blower.

The machine essentially consists of slightly inclined mixing cylinder rotatable in its bearings. In the top part of the drum there is a hopper for storing the sand and gravel. Into this hopper there is discharged at a predetermined rate water to give the materials the desired degree of moisture. At the

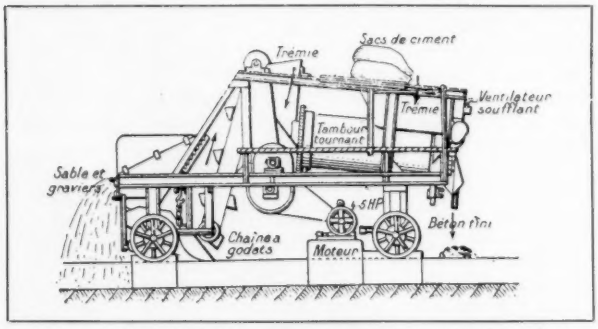


FIG. 2. DIAGRAMMATIC VIEW OF THE SPRENGER AERO-MALAXEUR CONCRETE MIXING MACHINE

(*Sable et graviers*—sand and gravel; *Tremis*—hopper; *Secs de ciment*—cement sacks; *Tambour tournant*—rotating drum; *Ventilateur soufflant*—blower; *Beton fini*—finished concrete; *Moteur*—motor; *Chaine a godets*—bucket elevator.)

other end of the cylinder there is a double proportioning hopper containing the binding elements, such as chalk, cement, or a mixture of the two. The graduated orifices admit these materials into the cylinder in a strictly predetermined proportion and a strong draft of air coming from a blower carries them to meet the materials coming from the other end of the drum.

As each grain of sand or gravel is projected from the upper hopper into the cylinder where it moves in an atmosphere filled with the binder, it is therefore entirely and intimately comixed with it.

The machine is of the continuous operation type and is entirely automatic, the concrete arriving at the bottom of the cylinder being discharged into cars or bins. It is claimed that with this machine the lack of uniformity of sand or gravel is less important than in the production of concrete by other means.—*La Nature*, No. 2444, February 5, 1921, pp. 95-96.

WATER COOLING TOWERS

By I. V. Robinson

Water cooling towers are extensively used in Great Britain in connection with the largest central stations where the plant has outgrown the natural supply of circulating water and has to supplement it by artificial means.

Water cooling apparatus differs considerably in type, but the principle and method of cooling is the same in all types and

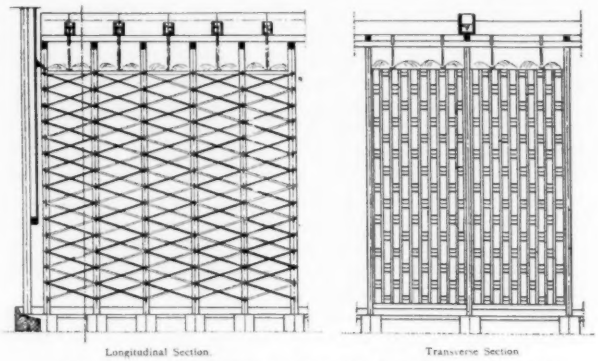


FIG. 3. DIAGRAMMATIC ARRANGEMENT OF COOLING STACK OF FILM COOLING TYPE

i.e., bringing into intimate contact with the hot water, a large quantity of air at a lower temperature.

The coolers are classified as follows:

1 Chimney type
  a natural draft
  b forced draft
2 Open type
3 Spray type

In a cooling tower heat is absorbed from the water by the air through two distinct actions: ((a) Direct heating of the air, and (b) evaporation of a portion of the water.

Under the usual working conditions in Great Britain the heat absorbed by evaporation is about 75 per cent of the total heat absorbed as shown by a brief calculation in the original article.

Of the various types of natural draft chimneys cooling towers are most generally used. The water is admitted at a height varying from 16 feet to 25 feet above the sea level and is distributed over the whole area of the tower by main distribution troughs. From these troughs it falls into smaller troughs pitched closer than the larger distribution troughs and is allowed to fall by various special methods differing with various makers on to the cooling staff. Air is admitted usually around the whole perimeter of the tower at the base of the stack, openings about 5 feet to 6 feet high being left for this purpose. The various designs differ mainly in the methods used for initially distributing the water over the cooling stack and bringing the water and air into intimate contact.

Cast iron or porcelain pipes may allow the water to fall into porcelain disks. If the water is under pressure and the height of fall and shape of disk proper, the whole thing may be broken into a fine spray.

Another method is to use dipper bars let into the side of the main distribution troughs. These bars have a concave surface along which the water flows, overflowing then on to the cooling stack. The object in all cases is to divide the water so that it presents a large surface to the air and yet at the same time to allow the air to ascend the tower freely.

It is because of this second condition that the splash system has not found much favor with designers lately.

Fig. 3 shows a section through a cooling stack which de-

pends upon film and not splash. After rebounding from the splasher disks under the small troughs, the water falls upon a number of inclined laths and flows down them. At the lower end of each lath there is a V in it through which the water passes and then falls upon the upper end of the next inclined lath and so repeats the process till the bottom is reached. In the stack illustrated the water flows over fourteen inclined laths, seven sloping in one direction and seven in the reverse direction. Each vertical set of laths is comparatively narrow and the sets are so arranged that adjacent laths at any level are inclined in the opposite direction. This alternate arrangement allows a free passage for the air up the stack, the air having to move horizontally only the width of one lath when passing each lath.

Towers are usually built over a tank varying in depth up to 6 feet, and the concrete forming the tank has an important bearing upon the stability of the tower. Many local authorities in England stipulate that a structure such as natural draft cooling tower shall be able to withstand a wind pressure of 30 pounds per square foot and do not consider that this condition is met unless the resultant of the horizontal wind pressure and the weight of the tower and the concrete tank to which it is securely attached passes through the middle third of the base.

The original article shows how these magnitudes are computed.

The author presents some facts, however, which would indicate that this regulation is excessively stringent, and believes that there would probably be an ample margin of safety if the resultant of the wind pressure and weight of tower and tank passed through the middle half of the base with the tank empty, as the effect of the water which is usually in the tank would be to bring the resultant into the middle third. (As regards the testing of cooling towers, it is necessary first to determine clearly the object of the test.) Manufacturers usually guarantee that when the tower is dealing with a stated quantity of water per hour at a given temperature it will reduce the temperature by a definite amount under specified atmospheric conditions; and if the object of the test is merely to ascertain whether or not this guaranty of performance has been maintained, the test is quite simple and very few tests on cooling towers pretend to do more than this. But if it is desired to test the tower completely so as to learn whether any improvement can be made, a much more detailed test becomes necessary, a matter which is briefly discussed in the original article.—*Beama* (a monthly journal devoted to the interests of British electrical and allied engineering), Vol. 8, No. 3, March, 1921, pp. 227-234.

Progress in Mining and Metallurgy

Abstracts of Papers and Recent Articles

Prepared Under the Auspices of the American Institute of Mining and Metallurgical Engineers

FIREDAMP IN THE GOLD MINES OF THE FAR EAST RAND

By T. N. Dewar

DURING the past few years trouble has been experienced in certain mines of the Far East Rand through occurrences of firedamp. As firedamp is generally associated with collieries, it created some surprise when it appeared in the gold mines. The collieries in the Far East Rand area are singularly free from firedamp and the death roll from explosions can be almost entirely credited to the gold mines.

In the Brakpan mines, the first accident happened March 19, 1913. A fissure was encountered at the face from which a large quantity of water issued, and the winze became partly flooded. A pump was installed to handle the water. In due course the water level fell suddenly, so a pumpman went down to ascertain the cause and found that the water had fallen about four inches from the hanging in the hollow. When he held his lamp up to make the inspection an explosion occurred and he sustained fatal injuries. Later on it was ascertained by tests that the gas was firedamp. Nobody suspected the occurrence at the time. It is obvious that the gas had accumulated behind the water in the hollow and was released by the lowering of the water level by the pump. The depth from the surface to the face of the winze was about 3,470 feet.

After describing a number of other instances the author arrives at the following conclusions:

It is noticeable from the occurrences described that the firedamp in the mines of the Far East Rand is found principally in the presence of upthrow faults, which bring the foot-wall shales into position for driving through. In the majority of cases, faulting and water seem necessary for the presence of gas. In some cases sulfureted hydrogen accompanies the firedamp, but not always. It is assumed by many people that the gas travels with the water down fault planes from the coal measures. The great problem is to account for the vertical movement of the gas of nearly 4,000 feet.

It would appear that in places there is a definite connection through faulting from the coal measures to the gold measures. The dolomites form a convenient water channel all over the area. They are jointed and large quantities of water lie in the crevices.

The difficulty is just why firedamp should not take the line of least resistance and escape up the faults to the surface, instead of traveling down them. The fact remains that firedamp is generally found in mines where the coal measures are developed above or where a connection with them is available through the dolomites for gas to travel. On the other hand, the gas is usually found actually in or about the foot-wall shales that are very jointed. Carbon is also found occasionally on the contact of the reef and the shale where, especially if associated with pyrites, a great enrichment of values takes place. Perhaps under heat and pressure some reaction may take place between the pyrites, water, and carbon in or under the shales to produce something in the shape of firedamp.

Redmayne, in "Ventilation of Mines," states that "a blower of firedamp has occurred from time to time in the famous Van Lead mine, near Llanidloes, in Montgomeryshire, the vein of which traverses rocks of the lower silurian age. It is difficult to account for the presence of firedamp at this mine as there are no carboniferous rocks in the neighborhood and decaying timber could not account for the existence of a blower of gas. Possibly it owes its origin to the decay of plant or animal life of the silurian period, and has been pent up through the succeeding ages, or it may be due to the chemical action of acidulated waters or mineral substances. It is a peculiar feature of the emissions at this mine that they are accompanied by sulfureted hydrogen."—Abstracted from the *Journal* of The Chemical, Metallurgical and Mining Society of South Africa.

RETORT FOR ASSAYING OIL SHALES FOR OIL YIELD

By L. C. Karrick

THIS paper describes the assay retort used by the Bureau of Mines in the research work on oil shales now in progress at the Intermountain experiment station of the bureau at Salt Lake City, Utah, and at the Colorado coöperative oil-shale laboratory, Boulder, Colo. The retort which was de-

veloped through experimentation in the Bureau's laboratories is recommended as a simple device for field and laboratory use where rapid assays are desired with results of duplicate tests agreeing within one per cent. In setting up the apparatus, great care must be exercised to see that it is air-tight. The paper gives specific directions for preparing contact surfaces.

It is important to use a sheet-metal jacket around the retort while heating, leaving about ¼-inch clearance at the sides and enough to clear the clamp screw on top. Notches are cut in the jacket for ring support and delivery tube. A cover of asbestos board is necessary to reflect heat down against the retort lid, otherwise oil will condense on the inner side of the lid and drip down on to the shale in the retort, thus causing losses by secondary distillation.

OPERATION OF THE RETORT

Crush the shale to pass a ¼-inch screen, and weigh out just enough to fill the retort (2) level full, permitting the charge to rest loosely in the retort. After the lid is fastened carefully in place and tested for leakage, place the retort in ring support (3), adjust jacket (11) and cover (12), start the burner (1), then fasten the graduated cylinder (9) and reflux condenser (10) tightly in place. Use a very small flame at first, so that no oil will appear within 45 minutes after starting. Before distillation makes any considerable progress, the interior or coolest shale should be at least as hot as the vaporizing temperature of the oil evolved, otherwise vapors will migrate to the central or coolest part and condense there, causing losses of oil by cracking on redistillation of the condensed oil.

When 2 or 3 cubic centimeters of oil have accumulated, the flame should be increased; it is imperative to distill rapidly after oil vapors begin. If oil first appears in about 45 minutes it will then be safe to double the size of the flame, and thereafter every 20 to 40 minutes increase the heat by an equal amount. The oil should accumulate in the graduate at a uniform rate, and the analyst will soon become adept at pushing the rate of retorting without exceeding the condenser capacity. With the average oil shale, the recovery when the actual oil-producing period is approximately 2 hours will be 5 per cent greater than when distillation lasts 6 hours. When distillation is completed in less than 2 hours, there is danger of inaccuracy from exceeding the condenser capacity, and undoubtedly from decomposition of oil vapors by excessive temperatures. Distillation should be rapid enough, however, to prevent stagnation of oil vapors within the hot retort or connection, and should progress at a uniform rate. If oil droplets appear dangerously near the top of the reflux condenser (10), the rate of heating must be retarded slightly.

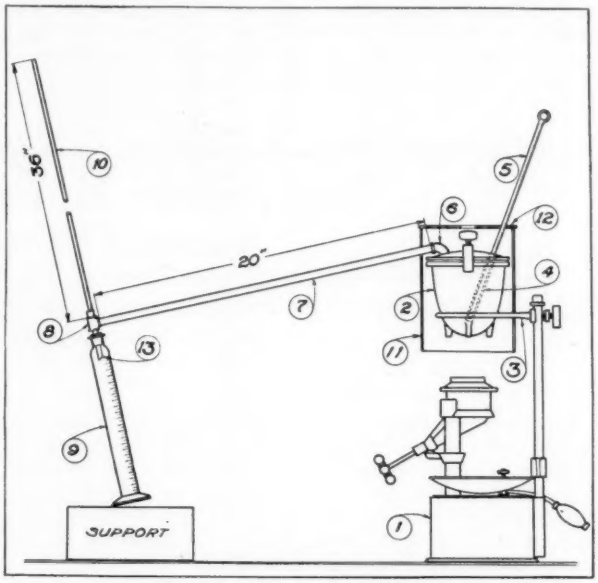
If retorting has progressed correctly, the rate of oil accumulation will decline suddenly as the last oil is distilled off, and, when this cessation becomes apparent, the flame should once more be increased the usual amount. A white gas may appear at the end of the run, but this has been found to be non-inflammable and to carry no oil vapors. The delivery tube should be kept fairly warm throughout the run, to prevent the oil from congealing therein. When the bottom of the retort has become a dull red, it can be safely assumed that the distillation of oil is completed, as this temperature is well above the final oil-yielding temperature for all oil shales.

MEASUREMENT OF THE OIL ACCUMULATED

Lack of experience in measuring the accumulated oil will cause a much greater error in results than lack of refinement in retorting technique, or imperfections in the retort.

The stoppered graduate and contents must be warmed until the oil is in a very fluid condition. Allow the oil to settle well, as some water is given off near the last stages of distillation, and will remain suspended in the partially congealed oil. In order to read accurately the volume of the oil and water, it is necessary to assist the formation of a perfect meniscus by releasing any oil and water clinging to the sides of the graduate. This is best accomplished by revolving the graduate, while still warm, between the palms of the hands. Read the upper level of the oil and then the lower level, if it is well defined and is not rendered obscure by emulsion, sediment, or clinging oil and water. The following procedure will facilitate accurate reading of the lower meniscus and also provide against the possibility that water sediment may not have settled out completely. Draw off with a pipette all except a few cubic centimeters of the oil while still warm, dilute the remaining oil with 10 to 20 cubic centimeters of clean gasoline, and agitate gently till the emulsion disappears. Allow the shale-oil and gasoline solution to settle, then draw off and add gasoline as before. Repeat as often as required, until a clear meniscus results. From the number of cubic centimeters of oil collected, calculate the gallons of oil per ton of shale.

The paper gives methods for more accurate measurement of the oil, together with a table of factors for facilitating calculations. The complete paper (Reports of Investigations, Serial No. 2229) may be obtained from the Bureau of Mines, Washington, D. C.



OIL SHALE ASSAY RETORT

1—Dangler Lamp; 2—C. I. Mercury Retort (1 pint); 3—Ring Stand; 4—Thermometer Well; 5—400° C. Thermometer; 6—Std. W. I. Street Ell; 7—¼" Std. W. I. Pipe; 8—Std. W. I. Tee; 9—100 cc. Graduate; 10—5/16" I. D. Pyrex Tubing; 11—Sheet Iron Shield; 12—Asbestos Cover; 13—¼" Pipe Nipple, cut at 45° angle.

INVESTIGATION OF FATIGUE OF METALS UNDER STRESS

By H. F. Moore

At present the writer is connected with an investigation of the so-called fatigue of metals under stress. So far we have studied the more fundamental and simple case of the repeated stress, without the additional complexity of impact, which might bring in other factors. We feel that this investigation which has been in active progress for a little over a year, has shown more conclusively than has been shown before that steel under repeated applications of stress, reversed from positive to negative, will not fail below some fairly clearly defined limiting stress, which so far as we can see, does not bear any definite relation to the ordinary elastic limit, being as large as the elastic limit in some cases and about one-half the elastic limit in others.

I do not know of any evidence in favo of the theory that metals materially change their crystalline structure under re-

peated stress. The crystals are broken under repeated stress. The second theory, advanced by Bauschinger, the German scientist, is that under repeated stress some inherent property of the material changes its elastic limit, it is an inherent property of the material, possibly some property of the amorphous cement between the crystals. The third view is that all fatigue of metals is the result of the spread of damage from little localized overstresses.

I do not feel justified in stating my positive belief in the third view as against the second, but I have yet to run across a case of failure of steel or other metal, either in the laboratory or in service that could not be explained by the gradual spread of damage from some nucleus.

In the steel work of any building there are undoubtedly many thousands of places where structural damage was done—where riveted members were bent into place cold and where the rivets were fitted with drift pins and things of that kind. locally, the steel in the building was stressed beyond its yield points in many places. These little localized overstresses do no damage at all; the building is entirely safe. But if this building were subjected eight or ten times a day to a mild earthquake, these little localized overstresses might be nuclei from which damage would spread and eventually we would have trouble. That is, these little localized overstresses may not be important if the structure is loaded a few times but they may be of importance if the structure is loaded many thousands of times.

So far we have seen no failure that could not be explained by localized high stress, at a nick, a crack, at a point where one heat treatment stopped and another began or where there was local faulting due to that fact, possibly due to a place where there was local blue brittleness—or any one of a dozen causes. Certainly in the case of drill rods the actual distribution of stress must be different from that which any mathematical analysis could predict. It would seem that the spread of damage from the localized overstresses, so far as we can see now, explains the phenomenon known as fatigue.—Abstract of paper presented at the New York Meeting, February, 1921.

INDEX

VOLUME III, JANUARY TO JUNE, 1921

Note.—Illustrated articles are marked with an asterisk (*), shorter articles and notes with the letter (n). Look for the general subject rather than the supposed specific title of any article. Thus under the headings "Aeronautics," "Automobiles," "Meteorology," etc., related articles may be found much more quickly than by referring to the title of the article.

A

ACOUSTICS. See SOUND.
AERONAUTICS.
- Aircraft in thunderstorms....(n)67
- Aircraft statistics....(n)567
- All-metal propeller. Leitner-Watts..(n)*380
- Aveline stabilizer....*359
- Balloon racing....(n)454
- Cause of engine failures....(n)467
- Driftograph....(n)*453
- Errors of direction finders....*451
- German airship construction during war *455
- International airship navigation....(n)67
- Leonardo da Vinci as aviation engineer *355
- Lighting for night flying....(n)458
- Looking into cylinder of engine....(n)556
- Seaplane forest patrol....(n)483
- Weather conditions in flight....68
- Wings, slotted....*66

AFRICA, PERSIAN COLONY IN....(n)491
AGRICULTURE. See also PLANTS.
- Carbon-dioxide as fertilizer....(n)141
- Cooling of soils without freezing....(n)300
- Electro-culture....(n)376
- Fertilizer, cyanamid changes in....(n)85
- Fertilizer, snow as....*315
- Radioactivity and soil fertility....415
- Wheat, increasing protein content....(n)77

ALCOHOL FROM WOOD WASTE....(n)275
ALCOHOLS, THE HIGHER....(n)181
ALLOYS. See METALS AND METALLURGY.
AMMONIA.
- Ammonia gas problem, solution....(n)560
- Mollier diagram, thermal properties..(n)372
- Properties of....(n)372
- Solubility of metals in....(n)436

ANIMALS.
- Alternation of generations....405
- Animal mind....*395
- Clinic for animals....*128
- Diet of captive apes....(n)502
- Eyeless salamander effect of light on (n)306
- Oxygen necessary for existence....37
- Seals, taking census of....*16
- Smallest in existence....*391
- Teeth, suppression in ruminants (corresp.)....*382

ANTHROPOLOGY, PRACTICAL VALUE OF....(n)466
APES, CAPTIVE, DIET OF....(n)502
APPLE, PHYSIOLOGY OF....(n)401
ARCHAEOLOGY.
- Ancient harbors of Ostia and Porto....*442
- Artists of glacial period....*199
- Astronomical rock carvings....*301
- Cliff dwellings in Mesa Verde....*9
- Egyptian life 4,000 years ago....*487
- Greek temple of 400 B.C....(n)445
- Tertiary man in Flanders fields....*303
- Trephining among prehistoric Indians (n)496

ARSENIC METALLIC....(n)83
ARTISTS OF GLACIAL PERIOD....*199
ASTRONOMY. See also RELATIVITY.
- Betelgeuse, diameter of....(n)195
- Betelgeuse, new astronomical marvel (n)99
- Celestial speed record....(n)111
- Measuring diameter of stars....*100
- Milky Way, recent studies....(n)6
- Infinitely small and infinitely great....388
- Limits of the Universe....4
- Planetary motions and the Einstein theories....484
- Pre-historic astronomy....*301
- Roger Bacon manuscript....*492
- Variability of the sun....(n)486

ATTAR OF ROSES....*409
AUTOMOBILES.
- Coats steam car....(n)*567
- Crating for export....(n)81
- Looking into cylinder of engine....(n)556
- Lumber in motor vehicle industry....(n)274
- Meeting on revision of tire specifications....(n)557
- Road shocks and rubber tires....(n)250

B

BACON, ROGER, MANUSCRIPT....*492
BACTERIOLOGY.
- Chemical war on disease....*503
- Eggs, tests of....(n)15
- Fragrance of the earth....(n)522
- Germs, banishing with silver spoons (n)324
- Menace of shaving brush....(n)387
- Molds and wood destroyers, difference (n)404
- Molds, effect of certain agents on...(n)84
- Pseudo-miracle of bloody sweat....(n)418
- Solvents produced by bacteria....(n)564
- Vaccines and serums....*507

BALLISTICS.
- Ballistic wind....437
- Dispersion of projectiles....(n)438
- Path of shell (correction)....190

BAGS, PAPER FOR CEMENT AND LIME....(n)557
BAKING, AMERICAN INSTITUTE OF (n)86
BALLOONS. See AERONAUTICS.
BASEBALL BATS, LAMINATED....(n)472
BILLIARD BALLS FROM IVORY....*316
BIOLOGY.
- Alternation of generations....405
- Artificial cells....*221
- Chemical construction and individuality 212
- Dynamics of plant respiration....28
- Effect of ions on movements of cilia...*511
- Effect of light on eyeless animals....(n)306
- Effect of light on plant growth....(n)78
- Gaseous exchange between roots and air....(n)217
- Heredity origin of mechanism of....(n)466
- Hybridization and evolution....(n)78
- Is oxygen necessary for animal existence?....37
- Leaves, mutation and evolution....*400
- Mechanical side of evolution....*121
- Mendelism, relation to natural selection....(n)369
- Place of life in nature....112
- Plants, prolonging life of....(n)117
- Protoplasm, viscosity values of....(n)314
- Relation of Mendelism to mutation and natural selection....(n)369
- Roger Bacon manuscript....*492
- Upward translocation of foods in plants....(n)310
- Vegetative and reproductive functions and metabolism....(n)522
- Why roots grow downward....*311

BIRDS.
- Bird that builds incubator....(n)399
- Do migratory birds prepare for flight?.(n)38
- Fritton decoy....*402
- Voice in young and adult....(n)392

BOARDS AND RESEARCH....*59
BOILER, WATER PURIFIER IN....(n)*282
BOLT, NOVEL TYPE OF....(n)467
BORON, DESERT VEGETATION AND..(n)77
BOTANICAL GARDENS OF NEW YORK *24
BRAKE, WATER, EDDY....(n)*184
BRASS, ELECTRO-DEPOSITION OF (n)278
BRICK, SAND LIME....(n)372
BRICK WALLS, STRENGTH TESTS. (n)557
BRIDGE AS TEST OF CIVILIZATION. *201
BRONZE, NEW STANDARD SAMPLES (n)320
BRUNNER MOND DECISION....(n)354
BUBONIC PLAGUE....(n)76
BUILDING MATERIALS, THERMO CONDUCTIVITY....*243
BUILDING INDUSTRY, RESEARCH IN WOOD....(n)244

C

CAMERA, FOR PHOTOGRAPHS IN RELIEF....*259
CANAL, RHINE-MAIN-DANUBE....(n)204
CANALS, GERMAN, HANSA TOWNS..(n)204
CANE, DUMB....(n)408
CAR, CONTAINER TYPE....*353
CARBON-DIOXIDE AS FERTILIZER..(n)141
CARBORUNDUM COATED FIRE-BRICK (n)82
CASTING STEEL PIPE CENTRIFUGALLY....(n)473
CATALYSIS, PRODUCING HEAT BY...*251
CAVE, CALCITE, STERLINGBUSH....*393
CELLS, ARTIFICIAL....*221
CEMENT FOR PORCELAIN....(n)180
CEMENT. See CONCRETE.
CERIUM, FERRO....(n)149
CHEMISTRY. See also DYES.
- Chemical construction and individuality 212
- Chemical industry in Czecho-Slovakia (n)464
- Chemical monographs....(n)563
- Chemist militant....(n)483
- Colloidal fuel....(n)85
- Colloidal state of matter....321
- Disease, chemical war on....*503
- Eggs, tests of....(n)15
- Electrical concentrator for sulphuric acid....(n)43
- Equations, method of balancing (corresp.)....286
- Future of theoretical chemistry....(n)471
- Industrial fellowships....(n)564
- Ionic dissociation theory....*140
- Light and chemical energy....*523
- Recent publications, Bur. of Stand...(n)468
- Report of the chemist....(n)234
- Sixty-first meeting Amer. Chem. Soc..(n)564
- Solvents produced by bacteria....(n)564
- X-rays, actions caused by....(n)262

CILIA, EFFECT OF IONS ON....*511
CLAY FOR PAPER....(n)373
CLAY, PROCESS OF AGING....(n)373
CLIFF DWELLINGS IN MESA VERDE.. *9
CLOTHS FOR MECHANICAL USES...(n)375
COAL. See also FUEL; MINES AND MINING.
- Air required to burn....(n)*58
- Alaskan fields....(n)285
- Assay for carbonization purposes....(n)469
- Mining in Spitsbergen....(n)380

COCOONS AND WEATHER....(n)15
COLLOIDS. See CHEMISTRY.
COLOR. See also DYES; LIGHT; PAINT.
- Colors for straw....(n)278
- Glass colors....(n)277
- Measuring shades of....231
- Visual illusions in arts....*497

CONCRETE.
Effect of reversals of stresses on beams (n)272
Fire resistance of building materials (n)467
Fire tests of building columns (n)371
Hardeners for concrete floors (n)154
Sprenger process (n)*568
Standard paper bags for cement (n)557
COPPER, THERMAL EXPANSION (n)94
COTTON AND GRASS (n)62
CRYOSCOPE AND EBULLIOSCOPE (n)36
CRATING AUTOMOBILES FOR EXPORT (n)81
CRATING, BETTER (n)275
CUBE, DUPLICATING THE (n)*361
CURVES, PHOTO-RATIOGRAPH *44
CYANAMID, CHANGES IN (n)85
CYCLONE, BENGAL'S DISASTROUS (n)486
CZECHO-SLOVAKIA, CHEMICAL INDUSTRY IN (n)464

D

DEAF, NEW MICROPHONE FOR (n)*361
DECOY, FRITTON *402
DENTAL AMALGAMS (n)79
DIAMOND, COMPRESSIBILITY OF (n)369
DIAMOND POWDER (n)374
DINOSAUR, NEW HORNED *7
DIRIGIBLES. See AERONAUTICS.
DOGWOOD, SAVE THE (n)414
DOORS, TO PREVENT WARPING (n)472
DRILLS, MAGNETIC TESTING OF (n)176
DRILLS, ROCK, BREAKAGE AND HEAT TREATMENT (n)477
DUNES, ORIGIN OF (n)198
DURALUMIN, CORROSION OF (n)558
DUST.
Blast furnace dust recovery *543
Laying dust with fog *419
Preventing explosions, problem *239
Ventilation in metal mines (n)187
DYES.
Chemical researches (n)471
Colors for straw (n)278
Cotton dyeing (n)170
Dye from prickly pear (n)86
Dyes again (n)82
Formula card (n)136
Improvements in dyeing (n)532
Influence of moisture on shades (n)278
Measuring shades of colors 231
New American dyes (n)563
What goods dye best? (n)200

E

EARTH, FRAGRANCE OF (n)522
EBULLIOSCOPE AND CRYOSCOPE (n)36
EDUCATION OF HANDICAPPED CHILDREN (n)178
EGGS, CHEMICAL AND BACTERIOLOGICAL TESTS (n)15
EGGS, FORMATION OF FERROUS SULPHIDE DURING COOKING (n)181
EGYPT ANCIENT MODELS *487
EINSTEIN. See RELATIVITY.
ELECTRICITY.
ELECTRO-DEPOSITION.
Electro-deposition of brass (n)278
Electroplating, coöperative work (n)175
Electro-sherardizing (n)280
Thermo-couples constructed by electro-deposition (n)*90
FURNACE.
Electric furnace in iron foundry (n)283
Electric furnace refractories (n)228
Electric steel industry (n)338
MISCELLANEOUS.
Attraction between conductor and semi-conductor *339
Battery, new electric *163
Concentrator for sulphuric acid (n)43
Effect of fibers on oil insulation (n)565
Electric heating impracticable (n)58
Electric fires (n)*475
Electric resistance thermometers (n)372
Electrical aids to navigation (n)377
Electrical dehydration of oil (n)87
Electrical expression of human emotion (n)340
Electrical resistance of metals (n)566
Electro-culture (n)376
Magnetic testing of drills (n)176
Moving platform for cross-town lines (n)565
National Safety code (n)468
New physical phenomenon *339
Oil prospecting by electric waves (n)377
Oscillograph, new portable (n)279
Phenomena in extreme vacuo *46
Photo-electric currents in the eye (n)370
Piezometer, testing force of explosives 337
Steel alloy for permanent magnets (n)156
Stored heat for spinning mill (n)156
Thermoelectricity and conductivity of metals (n)182
POWER AND TRANSMISSION.
Aluminum for transmission lines (n)280
Automatic hydroelectric plant (n)477
Barbed wire as protection against surges (n)162
Capturing electricity from air *39
Central stations in 1920 (n)281
Cooling large electrical machines (n)348
Direct current conversion (n)242
Distribution of electricity (n)565
Electric drive of ships (n)475
Electrically operated steam boilers (n)88
First 220,000-volt power transformer (n)377
Half wave and quarter wave transmission (n)89
Hydroelectric plant 5,400-ft. head (n)426
Hydroelectric progress in Canada (n)566
Industries and super-power (n)*473
Kaplan hydraulic turbine (n)279
Power from Norway to Denmark and Sweden (n)43
Rotor balancing machine (n)*378
Thury direct current system (n)87
Tides, 500,000 hp. from (n)3
Water-cooling towers (n)*569
WELDING.
How to weld cast iron (n)542
The welding arc 245
ELECTRO-CULTURE (n)376
ELECTRON, POSITIVE, SIZE (n)368
ELECTRONICS, INVESTIGATIONS IN (n)273
ELLIPSOGRAPH, ISOPERIMETRIC (n)*163
ENAMEL, VITREOUS, READING LIST (n)375
ENAMEL, WHITE, FOR CAST IRON (n)556
ENGINES AND MOTORS.
Carbonization of oils in internal combustion engines (n)175
Cause of airplane engine failures (n)467
Crankless steam engine (n)*474
Fuel savings in automotive engines (n)*185
Goldberg Diesel engine (n)*92
Junkers water eddy brake (n)*184
Liberty motor, ancestors of *247
Looking into cylinder during operation (n)556
Oil engine problems (n)281
ENGRAVING, ANCIENT GEM *168
ETCHING REAGENTS, NON-FERROUS (n)557
EXPLOSIONS, DUST, PREVENTING *239
EXPLOSIVES, TESTING WITH PIEZOMETER 337
EYE, PHOTOELECTRIC CURRENTS IN (n)370
EYE STRAIN IN CINEMAS (n)74

F

FABRICS. See TEXTILES.
FATIGUE, EXPERIMENT WITH REST PAUSES (n)186
FEET, WARMING IN BED (n)32
FELLOWSHIPS, INDUSTRIAL (n)564
FERRO-CERIUM (n)149
FERTILIZER. See AGRICULTURE.
FIBERS. See also TEXTILES.
Effect on insulation of oils (n)565
New fibers (n)181
Textile fibers identification *421
FIELD GLASSES FOR SEEING SUBMERGED OBJECTS 258
FIRE-BRICK, CARBORUNDUM (n)82
FIRE EQUIPMENT, SMOKE MASKS (n)468
FIRE FIGHTING EQUIPMENT, MODERN *329
FIRE-PROOFING FABRICS 171
FIRE RESISTANCE OF BUILDING MATERIALS (n)467
FIRE TESTS OF BUILDING COLUMNS (n)371
FIRES, ELECTRIC (n)*475
FLAVORS, ODORS AND INFRA-RED RAYS *519
FISH.
Devil fish as grappling irons (n)*23
Fish that bear young alive *21
Fish that chew cud 306
Fishes with prehensile tails *19
How bivalves feed *511
Lung fishes *118
Manta, monster devil fish *215
Marine borers *446
Seahorse *19
Toxicity of salts to fishes (n)271
FODDER, HAY CAKE (n)254
FOG, LAYING DUST WITH *419
FOOD.
Baking, American Institute of (n)86
Cattle feed of sawdust (n)81, (n)328
Detecting poisons in foods 325
Determining degree of sweetness (n)174
Diet of captive apes (n)502
Food investigations (n)276
Foods under the microscope *513
Ferrous sulphide in eggs during cooking (n)181
Hay cake for cattle (n)254
Increasing protein content of wheat (n)77
Manna 414
Maltose syrup situation (n)84
New facts about vitamines (n)222
Olive (n)26
Prickly pear (n)86
Searching for new food plants *516
Selection of food plants by insects (n)23
Substitute for milk and cream (n)328
Temperature and humidity in storage of eggs and candy (n)424
FORMALDEHYDE AND METAL CORROSION (n)179
FORMALDEHYDE IN LEATHER MANUFACTURE (n)181
FORESTRY. See also WOOD.
Factors controlling distribution of types (n)270
Naval stores (n)180
Research at Forest Products Laboratory (n)81
Research in boards *59
Save the dogwood (n)414
Seaplane forest patrol (n)483
Tropical forests 267
FRUIT, COMPOSITION OF GASES IN RIPENING (n)177
FRICTION AND LUBRICATION *319
FUEL. See also COAL.
Air required to burn pound of coal (n)*58
Charcoal method of gasoline recovery (n)70
Colloidal fuel (n)84
Fuel oil from maize (n)246
Fuel savings in automotive engines (n)*185
Fuel supply of the world (n)188
Future fuel (n)550
Gasoline by charcoal absorption process *252
Illuminating and heating gas from wood (n)277
New motor spirit (n)179
Oil shale industry (n)266
Palm oil as engine fuel (n)567
Petroleum refining problems (n)180
Power and fuel facts (n)184
FUR, DETECTION OF IMITATION *130
FUR, METHOD OF IDENTIFYING (n)286
FURNACE.
Blast furnace flue dust recovery *514
Blast furnace slag (n)181
Electric furnace in iron foundry (n)283
Electric furnace refractories (n)228
Electric steel industry (n)338
Turbine patent furnace (n)*379

G

GAS. See also FUEL, HYDROGEN AND OXYGEN.
Detecting leaking gas (n)471
Firedamp in gold mines (n)569
Gases in ripening of fruits (n)177
Modern fire fighting equipment *329
GASOLINE. See FUEL.
GEARS, STEEL, RESILIENT (n)74
GEM ENGRAVING *168
GEM, NEW, HELIODOR 227
GEOLOGY.
Center of the earth (corresp.) (n)189
Dinosaur, new horned *7
Is earth expanding or contracting (corresp.) (n)189
Land and water distribution (n)502
Living plants in solid rock (n)394
Movement of rock masses (n)465
Origin of dunes (n)198
Sterlingbush calcite cave *393
Studying glaciers with stereoscope (n)394
Tertiary man in Flanders fields *303
Volcanic architecture (Vesuvius) *110
Volcanism and mountain making (n)558
GEOPHYSICAL CHEMICAL PROBLEMS (n)372
GLACIERS, STUDYING WITH STEREOSCOPE (n)394
GLASS.
Glass colors (n)277
Glass tubing, measuring internal diameter (n)360
Rolled optical, uses of (n)84
Sealing with optically finished surfaces (n)420
GLUE ANALYSES (n)469
GLUE, CHEMICAL REACTION AFFECTING (n)472
GOLF BALL, EVOLUTION OF *434
GRAIN SCALE, TEST OF (n)174
GRASS AND COTTON (n)62
GRINDING, CYLINDRICAL, WORK SPEEDS (n)282
GRINDING, DIAMOND POWDER (n)374
GUM, YACCA, INDUSTRY (n)450
GYPSUM, PROPERTIES AND USES (n)273

H

HAY CAKE, NEW FODDER (n)254
HEAT.
Electric heating impracticable (n)58
Electric resistance thermometers (n)372
Illuminating and heating gas from wood (n)277
Mollier diagram for thermal properties (n)372
Producing heat by catalysis *251
Thermo-conductivity of building materials *243
Warming buildings with refrigerating plants *539
HELIODOR, IS IT NEW GEM? 227
HELIUM (n)373
HEMP, MANILA *255
HEREDITY, ORIGIN OF MECHANISM OF (n)466
HIBISCUS, TEXTILE FIBER FROM (n)132
HORNETS AND OTHER WASPS *307
HOSE COUPLING, AIR AND STEAM *63
HUMIDITY AND TEMPERATURE IN STORAGE OF EGGS AND CANDY (n)424
HYDROGEN BY NEW PROCESS (n)85
HYDROGEN, INDUSTRIAL APPLICATIONS OF *341
HYGIENE. See SANITATION AND HYGIENE.

I

ICE, PHYSICAL PROPERTIES OF (n)430
ICE, CRYSTAL STRUCTURE OF (n)266
ILLUSIONS, VISUAL, IN ARTS *497

INDUSTRIAL ENGINEERING. See also PSYCHOLOGY.
Comparative value of labor of workmen ..... (n)127
Health of underground worker..... (n)187
Protection of heads and eyes of workers ..... (n)272
Research in South Africa ..... (n)180
Rest pauses, experiment with..... (n)186
INFINITELY SMALL AND INFINITELY GREAT 388
INKS AND RIBBONS, TYPEWRITER... 536
INKSTAINS, REMOVAL OF..... (n)18
INSECTS.
Automatic photography of butterfly's wing ..... (n)15
Effect of kiln drying on wood borers.. (n)472
Hornets and wasps *307
Mutation and evolution *400
Selection of food plants..... (n)23
Smallest animal in existence..... *391
Weather and opening of cocoons..... (n)15
INSTRUMENTS. See SCIENTIFIC INSTRUMENTS.
INVENTOR, LEONARDO DA VINCI.... *263
INVENTIONS, CHINA'S OLDEST..... (n)234
IVORY, MAKING BILLIARD BALLS FROM *316

K

KELP, INDIAN USES *137
Correction ..... (n)408
KNOTS, "MOUNTAIN CRAFT"..... *554

L

LANGUAGE PROBLEM, INTERNATIONAL AUXILIARY 365
LARYNX, SPEAKING WITHOUT..... (n)211
LEAVES, MUTATION AND EVOLUTION *400
LEONARDO DA VINCI AS INVENTOR. *263
LEONARDO DA VINCI AS AVIATION ENGINEER *355
LEPROSY PROBLEM 75
LEATHER.
Acid process applied to tannery waste (n)470
Formaldehyde in manufacture of..... (n)181
Leather from rabbits' skins, tests.. (n)175
Permeability to water..... (n)83
LIGHT.
Determining stresses by polarized light.. *49
Effect on plant growth..... (n)78
Effect on so-called eyeless animals... (n)306
Flavors, odors and infra-red rays..... *519
Illuminating and heating gas from wood ..... (n)277
Light and chemical energy 523
Microscopy with ultra-violet light..... *219
Standard for "white light"..... (n)273
Visual illusions in arts *497
LIME.
Definitions and specifications..... (n)176
Lime in United States ..... (n)374
Properties and uses ..... (n)80
Standard paper bags for lime..... (n)557
LIMESTONE, CAUSES OF DISCOLORATION ..... (n)149, (n)557
LUBRICATION, WHAT IS? ..... (n)291
LUBRICANT, OZOCERITE AS 150
LUBRICANTS. See also OIL.
LUMBER. See FORESTRY; WOOD.
LUNG CAPACITY, TEST FOR..... (n)129

M

MAGNESIUM ..... (n)88
MAGNETIC TESTING OF TWIST DRILLS ..... (n)176
MAGNETS, NEW ALLOY FOR ..... (n)156
MANILA HEMP *255
MAN, TERTIARY, IN FLANDERS..... *303
MANNA, WHAT IS IT? 414
MANTA, CURIOUS HABITS OF..... *215
MATERIALS, PHYSICAL PROPERTIES OF ..... (n)371
MEASURES. See WEIGHTS AND MEASURES.
MEDICAL SCIENCE AND SURGERY. See also SANITATION AND HYGIENE.
Auto-serums, use of..... (n)399
Banishing germs with silver spoon.. (n)324
Bubonic plague ..... (n)76
Chemical war on disease *503
Clinic for animals *128
Our leprosy problem..... 75
Skin sores and boils among metal workers ..... (n)318
Therapeutic value of silicic acid.... (n)211
Trephining among prehistoric Indians (n)496
Vaccination, new theories and methods.. 30
Vaccines and serums *507
MEDICINE, GIVING PLANTS ..... (n)62
MENDELISM, RELATION TO NATURAL SELECTION ..... (n)369
MESA VERDE, CLIFF DWELLINGS IN.. *9
METALS AND METALLURGY. See also ELECTRICITY; FURNACE; COPPER; STEEL; MINES; WELDING; ETC.
Arsenic, metallic ..... (n)82
Centrifugally cast steel pipe..... (n)473
Committee on non-ferrous alloys..... (n)557
Copper and solubility of iron..... (n)469
Corrosion of soft metals ..... (n)372
Dental amalgams ..... (n)79
Discoloration of metal..... (n)441
Duralumin, corrosion of..... (n)558
Fatigue of metals under stress..... (n)570
Ferro cerium ..... (n)149
Formaldehyde and metal corrosion... (n)179
Iron, sources and production of..... (n)85
Magnesium ..... (n)88
Metal substitutes ..... I, 54; II, 145
Metal spraying, recent progress..... (n)182
Non-ferrous etching reagents..... (n)557
Patina, natural and artificial..... *229
Physical properties of materials..... (n)371
Purifying steel with titanium..... (n)109
Relation between boiling point and fusion point ..... (n)502
Romance of platinum *547
Special alloys ..... (n)84
Static and dynamic tensile tests, nickel steel ..... (n)285
Steel and bronze, standard samples.. (n)320
Severing metals by oxidation..... *142
Solubility of metals in ammonia.... (n)436
Substitutes for platinum..... (n)76, (n)550
Thermoelectricity and conductivity of metals ..... (n)182
Welding cast iron electrically ..... (n)542
METEOROLOGY.
Ballistic wind 437
Bengal's disastrous cyclone..... (n)486
Building wall around North Pole..... (n)198
Capturing electricity from air..... *39
Cloud photography *293
Clouds and their significance..... (n)104
Forecasting hurricanes..... (n)270
Predicting minimum temperatures... (n)70
Snow as fertilizer *315
Soils, degree of cooling without freezing ..... (n)300
Thunderstorms, aircraft in ..... (n)67
Weather and opening of cocoons..... (n)15
Weather conditions in flight..... 68
MICROSCOPY WITH ULTRA-VIOLET LIGHT *219
MILK AND CREAM, SUBSTITUTE.... (n)328
MINERAL INDUSTRIES, BY-PRODUCT EXPANSION ..... (n)94
MINERAL WAX 150
MINES AND MINING.
Alaskan coal fields ..... (n)285
Blasting with liquid oxygen..... *333
Coal mining in Spitsbergen ..... (n)380
Coal pillar drawing methods in Europe ..... (n)284
Dust ventilation in metal mines ... (n)187
Firedamp in gold mines ..... (n)569
German potash mines *151
Health of underground worker..... (n)187
Iron, sources and production of..... (n)85
Non-metallic by-product expansion.... (n)93
Potash in New Jersey greensands.... (n)94
Prospecting by electric waves..... (n)377
Skip hoisting for coal mines ..... (n)284
Twenty-foot shaft 7,000 ft. deep.... (n)478
MODELS OF EGYPTIAN LIFE..... *487
MOLDING PROCESS, THACHER, FOR PROPELLER BLADES ..... (n)381
MOLDS AND WOOD DESTROYERS, DIFFERENCE BETWEEN ..... (n)404
MOLDS, EFFECT OF CERTAIN AGENTS ON ..... (n)84
MOLECULES, IS IT POSSIBLE TO OBTAIN IMAGES ..... (n)460
MOLLIER DIAGRAM FOR THERMAL PROPERTIES ..... (n)372
MOLYBDENUM STEELS ..... (n)546
MOTHER OF PEARL, IMITATING 237
MOTION PICTURES.
Daylight bioscope ..... (n)87
Eye strain in cinemas ..... (n)74
Motion pictures shown in relief..... *531
MOTORS. See ENGINES AND MOTORS.
"MOUNTAIN CRAFT" *551
MOUNTAIN MAKING, VOLCANISM AND ..... (n)558
MOVING PLATFORM FOR CROSS-TOWN LINES ..... (n)565
MUTATION THEORY AND NATURAL SELECTION ..... (n)369

N

NAVAL STORES ..... (n)180
NAVIGATION, ELECTRIC AIDS TO.. (n)377

O

OCEANOGRAPHY, PHYSICAL ..... (n)465
OCTOPUS USED AS GRAPPLING IRON ..... (n)*22
ODOR, THE EARTH ..... (n)522
ODORS, FLAVORS AND INFRA-RED RAYS *519
OLIVE, THE ..... (n)25
OIL.
Carbonization of oils in engines..... (n)175
Detection in paints ..... (n)180
Effect of fibers on insulating power of oils ..... (n)565
Electrical dehydration ..... (n)89
Friction and lubrication *319
Hardening of oils (Japanese)..... (n)150
New oil plant from Congo ..... (n)418
Oil shale industry ..... (n)266
Palm oil as fuel ..... (n)567
Petroleum as source of soap..... 459
Prospecting by electric waves..... (n)377
Report of committee on lubrication (British) ..... (n)374
Retort for assaying oil shales..... (n)*569
Slushing oils for rust prevention.... (n)79
Synthetic production of petroleum.. (n)348
Watch oils ..... (n)85
Water horizons in wells, sealing .... (n)*93
What is lubrication? ..... (n)291
Whence comes petroleum..... (n)336
OIL ENGINE, PROBLEMS ..... (n)281
OPTICAL INDUSTRY 532
ORIENT ESSENCE *533
OSCILLOGRAPH, NEW PORTABLE... (n)279
OXYGEN.
Blasting with liquid oxygen..... *333
Necessary for animal existence?..... 37
Severing metals by oxidation..... *142
OXY-HYDROGEN TORCH *142
OZOCERITE AS A LUBRICANT..... 150

P

PAPER.
Book paper from Southern woods.... *439
Clay for paper ..... (n)373
Paper fabrics again ..... (n)518
Paper making materials ..... (n)562
Standard bags for cement and lime.. (n)557
Testing of paper ..... (n)371
Pulping properties of American woods (n)81
PAINT.
Detection of oils other than linseed.. (n)180
Paint for iron exposed to high heat... (n)436
Recent publications ..... (n)176
Spray painting *235
PAINTINGS, PREHISTORIC *199
PAINTINGS, X-RAY TESTS OF *165
PATINA—NATURAL AND ARTIFICIAL *229
PEARL, MOTHER OF, IMITATING..... 237
PEARLS, ARTIFICIAL *533
PEARS, PRICKLY ..... (n)86
PEARS, RIPENING AND STORAGE.. (n)218
PERFUME, ATTAR OF ROSES..... *409
PERFUMES, CARE AND AGING..... (n)413
PERSIAN COLONY IN AFRICA..... (n)491
PERSPIRATION, RED COLORED..... (n)418
PHOTOGRAPHY.
Automatic, of butterfly's wing..... (n)15
Cloud photography *293
Developing without a dark room..... 526
Photographic researches ..... (n)260
Photographs in relief *259
Toning photographic prints..... 431
PHOTO-RATIOGRAPH *44
PHYSIOLOGY.
Cult of sound body *33
Comparative value of labor of workmen ..... (n)127
Height, hygiene and physical training (n)559
New physical tests for a man..... (n)559
Photo-electric currents in eye..... (n)370
Speaking without larynx ..... (n)211
Test for lung capacity..... (n)129
PHYTO-CHEMICAL RESEARCH..... (n)178
PIEZOMETER, TESTING FORCE OF EXPLOSIVES 337
PIPE, CENTRIFUGALLY CAST ..... (n)473
PIPE ORGAN, SINGING ..... (n)291
PIPE, WROUGHT FOR HIGH PRESSURES ..... (n)473
PLANTS. See also AGRICULTURE.
Absorption transpiration ratio ..... (n)177
Alternation of generations..... 405
Anatomical reduction in some Alpine plants ..... (n)271
Botanical Gardens of New York..... *25
Desert vegetation and boron ..... (n)77
Dumb cane ..... (n)408
Dynamics of plant respiration..... 28
Effect of light on growth ..... (n)78
Electro-culture ..... (n)376
Excretion in plants 417
Floral fireworks ..... (n)*120
Gaseous exchange between roots and air ..... (n)217
Giving medicine to ..... (n)62
Hybridization and evolution..... (n)78
Hibiscus, textile fiber from..... (n)132
How young defend against starvation (n)408
Living plants in solid rock..... (n)394
Optimum nutrient solutions ..... (n)177
"Oven plant" ..... (n)518
Phyto-chemical research, new fields.. (n)178
Plant that feeds on animals..... *218
Prolonging life of ..... (n)117
Searching world for new food plants.. *516
Selection of food plants by insects... (n)23
Tercentenary of potato ..... (n)214
Upward translocation of foods..... (n)310
Vegetative and reproductive functions and metabolism ..... (n)522
Why roots grow downward..... *311
PLASTER, COLORED ..... (n)149, (n)372
PLATINUM, ROMANCE OF *547
PLATINUM, SUBSTITUTES FOR (n)76, (n)550
POISON FOR RODENTS ..... (n)257
POISON—TOXICITY OF SALT TO FISHES ..... (n)271
POISONS, DETECTING IN FOODS..... 325
POLE, BUILDING WALL AROUND... (n)198
POLES, NEW PRESERVATIVE FOR.. (n)476
PORCELAIN, CEMENT FOR ..... (n)180
PORCELAIN, DECORATION OF ..... (n)470
PORT, NEW, FOR ROME..... *442
POSTS, SPLIT AND ROUND..... (n)472
POTASH.
American potash industry ..... (n)276
German potash mines *151
New Jersey greensands ..... (n)94
POTATO, TERCENTENARY OF ..... (n)214
POTTERY, INDIAN, AID FOR..... (n)8
POWER. See ELECTRICITY; ENGINES AND MOTORS.
Automatic hydroelectric plants..... (n)477

Electric drive for ships *475
Hydraulic propulsion of ships.....(n)*378
Hydroelectric plant, 5,400-ft. head..(n)426
Industries and superpower .....(n)*473
Kaplan hydraulic turbine .....(n)279
Power and fuel facts .....(n)184
Report on tidal power (British Board of Trade) .....(n)186
Tides, 500,000 hp. from .....(n)3
Turbine patent furnace .....(n)*379
Wind power .....(n)242
PROJECTILES, BALLISTIC WIND.....437
PROJECTILES, DISPERSION OF.....(n)438
PROPELLER BLADES, THACHER MOLDING PROCESS .....(n)381
PROPULSION ELECTRIC FOR SHIPS.(n)475
PROPULSION, HYDRAULIC .....(n)*378
PROTOPLASM, VISCOSITY VALUE OF .....(n)314
PSYCHOLOGY. See also INDUSTRIAL ENGINEERING.
Animal mind *395
Bridge as test of civilization.....*201
Cult of sound body *33
Electrical expression of human emotion .....(n)340
Measuring vocational fitness *205
Mental testing of handicapped children .....(n)178
Principles of modern psychology.....501
PULP. See PAPER.

R

RABBITS' SKIN LEATHER, TESTS..(n)175
RADIOACTIVITY AND SOIL FERTILITY 415
RADIO-TELEGRAPHY AND TELEPHONY.
Audion, recent applications of .....(n)87
Automatic printer *155
Eccles on wireless progress.....(n)183
Errors of direction finders *451
Progress in 1920 .....(n)176
Radio communication *157
RADIUM .....(n)371
RADIUM INSTITUTE IN PARIS *223
RAILROADS.
Carloads of safes *353
Marvel of train control *63
Moving platforms for cross-town lines (n)565
Recording speed indicators .....(n)*185
RATS, POISON FOR .....(n)257
RELATIVITY.
Einstein award .....(n)99
Einstein theories 292
Planetary motions and Einstein theories 484
Quest of the absolute 196
REFLECTOMETER, SIMPLE, PORTABLE .....(n)364
REFRACTORIES, ELECTRIC FURNACE .....(n)228
REFRIGERATION.
Ammonia problem and solution....(n)560
Columbian flask steam condenser....(n)567
Non-condensible gases .....(n)176
Refrigeration constants .....(n)556
Warming buildings with refrigeration plants *539
RESEARCH.
Ammonia gas problem solution .....(n)560
Brunner, Mond decision .....(n)354
Chemical researches in dyestuffs ....(n)471
Industrial research in South Africa..(n)180
Photographic researches .....(n)260
Phyto-chemical, new fields .....(n)178
Research and boards *59
Research in wood .....(n)81
Textile fibers .....(n)173
Turning losses to profit.....(n)265
Wire ropes .....(n)91
Wood for building industry .....(n)244
REST PAUSES, EXPERIMENT WITH (n)186
ROOFING TILES, DISINTEGRATION OF .....(n)244
ROOTS, GEOTROPIC ACTION OF.....*311
ROPE AND TWINE, MANUFACTURE OF *349
ROPE, MANILA HEMP *255
ROPES, WIRE, RESEARCH.....(n)91
ROSES, ATTAR OF *409
ROTOR BALANCING MACHINE ...(n)*378
RUBBER.
Brazil's white gold *133
Road shocks and tires .....(n)250
Rubber analysis .....(n)179
Rubber jar rings .....(n)79
RUSSIA, SCIENTIFIC WORK IN.....461
RUSSIAN ACADEMY OF SCIENCE.....561
RUST PREVENTION, SLUSHING OILS FOR .....(n)79

S

SALAMANDER, EYELESS, EFFECT OF LIGHT ON .....(n)306
SALINITY OF SEA WATER .....(n)559
SALT WELLS OF CHINA *427
SAND BLASTING .....(n)283
SAND LIME BRICK.....(n)372
SANITATION AND HYGIENE.
Health of underground worker.....(n)187
Height, hygiene and physical training .....(n)559
Laying dust with fog.....*419
Protecting heads and eyes of workers (n)272
Skin sores and boils among metal workers .....(n)318
SAPORIMETER *519
SAWDUST, CATTLE FOOD FROM (n)81, (n)328
SCALE, GRAIN, TEST OF .....(n)174
SCHOOLS, REORGANIZATION OF SCIENCE IN .....(n)276
SCIENCE FOR THE MILLIONS 462
SCIENCE, REORGANIZATION IN SECONDARY SCHOOLS .....(n)276
SCIENCE, RUSSIAN ACADEMY OF.....561
SCIENTIFIC AMERICAN MONTHLY, PLEA TO READERS .....(n)387
SCIENTIFIC INSTRUMENTS.
Ebullioscope and cryoscope .....(n)36
For seeing submerged objects.....258
Isoperimetric ellipsograph .....(n)*163
Photo-ratiograph *44
Simple, portable reflectometer.....(n)364
Testing physical development.....*33
SEAHORSE *19
SEALS, TAKING CENSUS OF *16
SEAWEED, INDIAN USES *137
SHAFT, 7,000 FT. DEEP .....(n)478
SHAVING BRUSH, MENACE OF.....(n)387
SHELL, PATH OF (correction).....190
SILICIC ACID, THERAPEUTIC VALUE OF .....(n)211
SILK EXPOSITION .....(n)563
SILK FROM SLAUGHTER HOUSE...(n)132
SKIP HOISTING FOR COAL MINES..(n)284
SLAG, BLAST FURNACE .....(n)181
SLIDE RULE, EXTRACTION OF FIFTH ROOT .....(n)104
SMOKE MASKS FOR D. C. FIRE DEPARTMENT .....(n)468
SNAKES, ARE THEY HARMLESS?.... 14
SNOW AS FERTILIZER *315
SOAP.
Petroleum as source 459
Soap analysis .....(n)318
Solutions, true nature of 538
SOAPSTONE AND TALC, USES OF ...(n)8
SOIL FERTILITY AND RADIOACTIVITY 415
SOILS, COOLING WITHOUT FREEZING .....(n)300
SOUND.
Experimental phonetics *527
Minimum sound energy for audition.(n)558
Nature of vowel sounds.....*361
New microphone for the deaf.....(n)364
Singing pipe organ .....(n)291
Submarine steam whistle *71
Voice in young and adult birds.....(n)392
SPEED INDICATOR, RECORDING....(n)*185
SPITSBERGEN, COAL MINING IN....(n)380
SPRINGS, HELICAL .....(n)*91
STAINS, INK, REMOVAL OF .....(n)18
STANDARDS COMMITTEE .....(n)557
STEAM.
Columbian flask steam condenser ...(n)567
Electrically operated boilers .....(n)88
Submarine whistles *71
Hose coupling *63
STEEL.
Artificial seasoning of gage steels....(n)80
Alloy for permanent magnets .....(n)156
Breakage and heat treatment of rock-drill steel .....(n)477
Effect of carbon phosphorous and manganese on mechanical properties ..(n)381
Electric steel industry .....(n)338
Hardness produced by abrasion.....(n)175
Molybdenum steels .....(n)546
New process for making.....(n)564
New standard samples .....(n)320
Nickel steel, tests .....(n)285
Pipe cast centrifugally .....(n)473
Purifying ingots with titanium.....(n)109
Reading list of vitreous enamel on steel .....(n)375
Stainless steel .....(n)373; 425
Standard samples of Bur. of Stand. ..(n)80
Temper brittleness .....(n)175
Uranium steels, tests.....(n)375
Wizards, past and present .....(n)179
STORAGE, TEMPERATURE AND HUMIDITY .....(n)424
STRAW, COLORS FOR .....(n)278
STRESSES, DETERMINING BY POLARIZED LIGHT *49
SUBMERGED OBJECTS, SEEING.....258
SUGAR, WHITE, IN NATAL.....(n)179
SULPHURIC ACID, ELECTRICAL CONCENTRATOR FOR .....(n)43
SWEAT, BLOODY .....(n)418
SWEETNESS, DETERMINING DEGREE OF .....(n)174
SYRUP, MALTOSE, SITUATION .....(n)84

T

TACHOGRAPH .....(n)*185
TALC AND SOAPSTONE, USES OF ...(n)8
TANNERY WASTE, ACID PROCESS APPLIED TO .....(n)470
TASTE, MEASURING THE DEGREES OF *519
TEETH, SUPPRESSION IN RUMINANTS (corresp.) *382
TELEGRAPHY AND TELEPHONY.
Earth current telegraphy .....(n)338
Multiple telegraphy and telephony...(n)48
New microphone for the deaf.....(n)*361
TELESCOPE FOR SEEING SUBMERGED OBJECTS 258
TEMPERATURE AND HUMIDITY IN STORAGE OF EGGS AND CANDY..(n)424
TEREDO, IN SAN FRANCISCO BAY ...*446
TEXTILES.
Artificial woolens .....(n)86
Chemical research in fibers .....(n)173
Fiber from hibiscus .....(n)132
Fibers, identification of *421
Fire-proofing fabrics 171
Grass and cotton .....(n)62
New fibers .....(n)181
Paper fabrics again .....(n)518
Resistance of fibers to high temperatures .....(n)174
Silk exposition .....(n)563
Silk from slaughter house.....(n)132
What goods dye best? .....(n)200
THERAPEUTICS. See MEDICAL SCIENCE AND SURGERY.
THERMOMETERS, ELECTRIC RESISTANCE .....(n)372
THERMOMETERS, PARTIAL IMMERSION .....(n)468
TIDAL POWER, REPORT OF BRITISH BOARD OF TRADE .....(n)186
TIDES, HALF A MILLION HORSEPOWER FROM .....(n)3
TILE, DISINTEGRATION OF .....(n)244
TIMBER, MARINE BORERS *446
TIRE SPECIFICATIONS, REVISION OF .....(n)557
TITANIUM, PURIFYING STEEL WITH .....(n)109
TREPHINING AMONG PREHISTORIC INDIANS .....(n)496
TURBINE, HYDRAULIC, KAPLAN ...(n)279
TWINE AND ROPE, MANUFACTURE..*349
TYPEWRITER INKS AND RIBBONS....536

V

VACCINATION. See MEDICAL SCIENCE AND SURGERY.
VACCINES AND SERUMS *507
VACCINE, USE OF AUTO SERUMS..(n)399
VACUUM, ELECTRIC PHENOMENA IN..*46
VIBRATION ABSORBERS, COMPARATIVE STUDY .....(n)470
VIBRATIONS, PHOTO-RATIOGRAPH *44
VITAMINES, NEW FACTS ABOUT....(n)222
VOICE. See SOUND.
VOLCANOES. See GEOLOGY.

W

WALLS, STRENGTH TESTS .....(n)557
WASPS AND HORNETS *307
WASTE.
Acid process applied to tannery waste (n)470
Ethyl alcohol from wood waste.....(n)275
National survey of .....(n)195
Turning losses to profit .....(n)265
Utilization in mineral industries .....(n)93
WATCH, LIMITATIONS AS PRECISION INSTRUMENT .....(n)566
WATER.
Hydraulic propulsion of ships .....(n)*378
Purification .....(n)277
Purifier in vertical boiler .....(n)*282
Salinity of sea water .....(n)559
Water-cooling towers .....(n)*568
Wrought pipe for high pressures...(n)473
WEIGHTS AND MEASURES.
Device for measuring internal diameter of tubing .....(n)360
Extraction of fifth roots by slide rule (n)104
Infinitely small and infinitely great....388
Interferometer, astronomical application *100
International Bureau of *105
Small length measurements .....(n)79
Table of certain .....(n)80
Test of grain scale .....(n)174
Thirteenth annual conference .....(n)272
Ultra-micrometer .....(n)*90
WELDING.
German machines, recent .....(n)183
How to weld cast iron electrically...(n)542
The welding arc 245
WELLS, OIL, SEALING WATER HORIZONS .....(n)*93
WHEAT, INCREASING PROTEIN ....(n)77
WHISTLES, STEAM, SUBMARINE.....*71
WIND POWER .....(n)242
WIRELESS TELEGRAPHY AND TELEPHONY. See RADIO TELEGRAPHY AND TELEPHONY.
WOOD. See also FORESTRY.
Difference between molds and wood destroyers .....(n)404
Doors, to prevent warping.....(n)472
Effect of kiln drying on wood borers (n)472
Ethyl alcohol from wood waste .....(n)275
Laminated baseball bats .....(n)472
Lumber in motor-vehicle industry....(n)274
Moisture and properties of wood..(n)82
New preservative .....(n)476
Research and boards *59
Split posts and round posts.....(n)472
Wood for building industry .....(n)244
WOOLENS, ARTIFICIAL .....(n)86

X

X-RAYS.
Chemical actions caused by .....(n)262
Examination of material .....(n)476
Tests of old paintings *165
X-ray detective *261

Y

YACCA GUM INDUSTRY .....(n)450

Z

ZINC, ELECTRO SHERARDIZING....(n)280

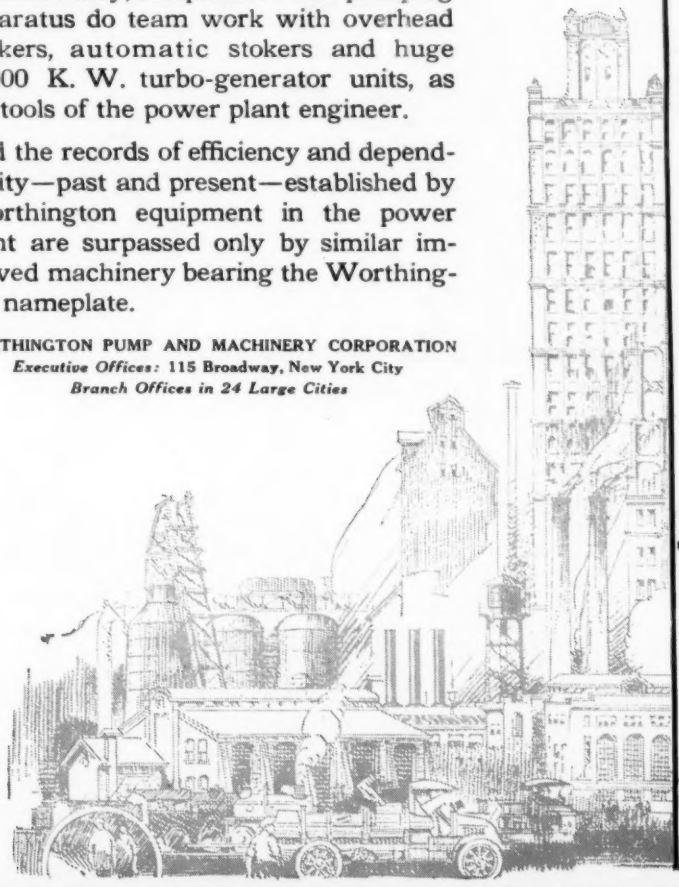
Thirty years ago —and now

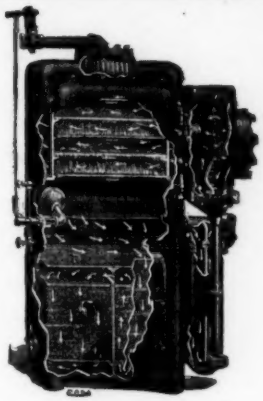
THIRTY YEARS AGO, when power plants were small, low powered and dirty—when hand firing and belt-driven dynamos were accepted practice, Worthington power plant apparatus was already earning a reputation for economy and utility.

Now, Worthington Feed Heaters, condensing machinery, compressors and pumping apparatus do team work with overhead bunkers, automatic stokers and huge 60,000 K. W. turbo-generator units, as the tools of the power plant engineer.

And the records of efficiency and dependability—past and present—established by Worthington equipment in the power plant are surpassed only by similar improved machinery bearing the Worthington nameplate.

WORTHINGTON PUMP AND MACHINERY CORPORATION
Executive Offices: 115 Broadway, New York City
Branch Offices in 24 Large Cities

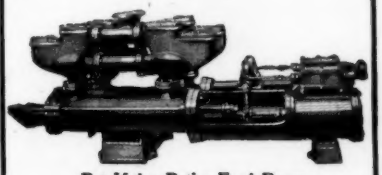




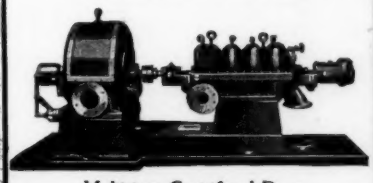
Open Feed Water Heater "Stilwell" Type

Combines in one unit a Feed Water Heater, a Feed Water Purifier, a Condensate Receiver and a Feed Water Softener. Marked economies and increase in boiler capacity follow its installation in steam plants.

Surface Condenser



Pot Valve Boiler Feed Pump



Multistage Centrifugal Pump Boiler Feed Pattern

B[13]

PUMPS—COMPRESSORS—CONDENSERS—OIL & GAS ENGINES—METERS—MINING—ROCK CRUSHING & CEMENT MACHINERY

WORTHINGTON

Deane Works, *Holyoke, Mass.*
Blake & Knowles Works *East Cambridge, Mass.*
Worthington Works *Harrison, N. J.*
Laidlaw Works, *Cincinnati, Ohio.*
Hazleton Works, *Hazleton, Pa.*
Gas Engine Works, *Cudahy, Wis.*
Power & Mining Works *Cudahy, Wis.*
Snow-Holly Works *Buffalo, N. Y.*
Epping-Carpenter, *Pittsburgh, Pa.*

REPRINTED

from the MAY ISSUE *of the*

SCIENTIFIC AMERICAN MONTHLY

TO OUR READERS

THIS is a plea for counsel. We are trying to perform a real service to our readers—to produce a journal that will be indispensable to the lover of science and to the man who would keep abreast of the progress of technology. How nearly this purpose is fulfilled we can only tell by hearing from our readers.

Were our field confined to a single branch of science, it would be a simple matter to keep pace with all the latest developments, but we are trying to cover the whole realm of science. The avenues of research are so many and varied, progress is so rapid, there is so much to crowd into our limited number of pages, that we must ever struggle with the problem of what best serves our readers. Our choice would be better guided if we knew what subjects were of superior interest to the majority of our readers.

Accordingly, will you not give us the benefit of your criticism and advice? Tell us what branch of science interests you most. What subjects would you like to see treated at greater length? Is there any field which, in your opinion, we are neglecting, or to which we are devoting too much space? Do you read the SCIENTIFIC AMERICAN MONTHLY for the pure love of science and progress? Do you derive any industrial or commercial benefit from it?

Constructive criticism is invaluable to an editor. Answers to the questions we have put will help us to produce a journal which will be of highest interest and real service to you.

PUBLICATIONS, like men, improve on the constructive counsel of friend and associate. . . . And many times the best form of expression is open criticism.

In the May issue of SCIENTIFIC AMERICAN MONTHLY we sought the advice of our readers regarding their needs in the technical journal. The letters that were received contain many suggestions and criticisms that will bring definite improvements in the service of SCIENTIFIC AMERICAN MONTHLY to its readers.

Recognizing however the boundless field of suggestion, we are repeating the request in the hope that we may keep pace with as many of the technical demands of our readers as possible. Your letter will be received with the highest interest.

In the combined work of the weekly SCIENTIFIC AMERICAN and the MONTHLY we aim to give a complete grasp of the work of scientist, engineer, chemist and manufacturer—a grasp based on the combination of weekly digest and the complete treatment of the monthly journal.

One of the letters has given apt expression to this double function: "In the SCIENTIFIC AMERICAN WEEKLY we get the practical side of science and in the MONTHLY the layman receives the latest conclusions of the specialist in all fields of science." In such a manner the Scientific American publications aim to serve their readers.

To the subscribers of the SCIENTIFIC AMERICAN MONTHLY who are not now receiving the weekly periodical, we offer the advantage of combining the two subscriptions at reduced rate. Yearly subscription for the WEEKLY—52 issues—is $6. SCIENTIFIC AMERICAN MONTHLY is $7; in combination the two subscriptions are $11 per year. We will start your subscription for the MONTHLY from date to correspond with your subscription for the weekly SCIENTIFIC AMERICAN, billing you pro rata on the year-combination of $11.

SCIENTIFIC AMERICAN PUBLISHING COMPANY

WOOLWORTH BUILDING, NEW YORK